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THE ASTROPHYSICAL JOURNAL

AN INTERNATIONAL REVIEW OF SPECTROSCOPY
AND ASTRONOMICAL PHYSICS

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APRIL 1920

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VOLUME LI APRIL 1920 NUMBER 3

POLARIZATION OF RADIATION BY GRATINGS

By L. R. INGERSOLL

ABSTRACT

Polarizing effect of gratings.—(1) *Reflected radiation.* After a brief review of previous investigations, both theoretical and experimental, the author points out that while the Rayleigh-Voigt theory predicts an anomalous effect for a wave-length equal to the grating space, no experimental investigation of polarization effects for a range of wave-lengths which includes the grating space has been made. Accordingly the author *tested four speculum gratings*, whose grating space varied from 1.2 to $2.7\ \mu$, with plane polarized light of wave-length 0.5 to $2.3\ \mu$, and obtained the reflecting power of the ruled surface relative to the polished unruled surface for normal incidence. With the polarization (electric vector) perpendicular to the rulings, a sharp minimum was found at a wave-length equal to the grating space and also, in some cases, for approximately one-half and one-third this value. Observations made with an incidence of $7°$ gave two minima at wave-lengths equal to the grating space multiplied by $(1 \pm \sin\theta)$. As the curves show, the polarizing action depends not only on the wave-length but also on the particular grating used; and since polishing the gratings resulted in practically no change the effect must depend upon the groove form. (2) *Transmitted radiation.* The author also *tested some collodion replica gratings* with spaces of either 1.0 or $1.6\ \mu$. The transmitted light was found to be partially polarized at right angles to the rulings; also the polarizing effect showed maxima for wave-lengths equal to the grating space and to half that value. (3) *Radiation diffracted tangentially* from the speculum gratings showed a marked polarization at right angles to the rulings. (4) *Conclusions.* These experiments show that the excess of perpendicularly polarized energy present in light tangentially diffracted from a reflecting grating is accompanied by a deficiency in radiation of this polarization in the directly reflected beam; thus they tend to confirm the Rayleigh-Voigt theory.

Use of gratings in studying polarization phenomena.—The results of these experiments *suggest* that it would be advisable to avoid angles of incidence at which the light being studied is tangentially diffracted in any higher order.

The present work is a study of the polarization of the undiffracted, i.e., directly reflected, light from ordinary speculum metal gratings for the range of wave-length $0.5\ \mu$ to $2.3\ \mu$. The directly transmitted beam has also been studied for a number of collodion replica gratings.

Polarization by gratings, as well as the related case of polarization by slits, has been extensively investigated both theoretically and experimentally but will be only very briefly[1] reviewed here. The observation of Fizeau[2] that light is more readily transmitted by a very narrow ($0.1\ \mu$) slit when its polarization[3] is such that the electric vector vibrates in a direction perpendicular to the edges has been verified by Ambronn[4] and others, and is in agreement with the theory of Rayleigh[5] for narrow openings in a thin screen. For slightly wider slits ($>\frac{1}{3}\lambda$), vibrations parallel to the slit are transmitted somewhat better than the others. The theory is not applicable when the slit-width approaches equality with the wave-length.

Wire gratings show polarization effects somewhat analogous to narrow slits. When the wave-length is larger than the grating space—the Hertzian case—vibrations perpendicular to the wires are more readily transmitted. This case has been theoretically investigated by J. J. Thomson,[6] H. Lamb,[7] and others, while on the experimental side Du Bois and Rubens,[8] using a wide spectral region including some long *Restrahlen,* found for fine wire gratings a Hertzian polarization for wave-lengths longer than a certain

[1] For a more extended list of references see paper by Du Bois and Rubens, *Philosophical Magazine* (6), **22**, 322, 1911.

[2] *Annales de Chimie et de Physique*, **63**, 385, 1861.

[3] Following recent practice, the direction of polarization, as referred to in the present paper, will always be that of the electric vector.

[4] *Wiedemann's Annalen*, **48**, 717, 1893.

[5] *Proceedings of the Royal Society* (A), **89**, 194, 1913.

[6] *Recent Researches in Electricity and Magnetism*, p. 425 (Oxford, 1893).

[7] *Proceedings of the Mathematical Society of London*, **29**, 523, 1893.

[8] *Wiedemann's Annalen*, **49**, 593, 1893; *Philosophical Magazine* (6), **22**, 322, 1911.

fraction of the grating space. For shorter wave-lengths an inversion occurred and the polarization changed sign, reaching a maximum in the neighborhood of 1 μ.

Rayleigh[1] has developed a theory applicable to ordinary reflecting gratings and this has been extended by Voigt,[2] account being taken of the optical constants of the metal on which it is ruled. Voigt and Collet[3] and Pogany[4] have carried out experiments in support of this theory, measuring amplitude and phase relations in the diffracted light. Of the earlier work on grating polarization, perhaps that of Fröhlich[5] is the most extensive.

An interesting point in the Rayleigh-Voigt theory, and one with which we shall be somewhat concerned in the present work, is a prediction to the effect that when a given wave-length in the spectrum of any order is just passing (tangentially) off the grating, the same wave-length in lower orders will be abnormally increased in intensity. This effect, however, is confined to the electric vector vibrating in a direction perpendicular to the rulings, while the light which is just passing off tangentially is completely polarized in this sense. This seems to explain some of the anomalies found by Wood,[6] particularly with gratings ruled on silver. These effects were profoundly modified, however, by even the slightest rubbing with soft chamois skin, so that they are apparently due to the sharp ridges rather than the bottoms of the grooves.

Present investigation.—It may be remarked that previous investigations in this line have, in general, been limited to radiation somewhat shorter in wave-length than the grating space, or else very much longer. An exception is the work of DuBois and Rubens; but with *Restrahlen* it is of course impossible to secure a continuous series of wave-lengths. It seemed worth while, then, to investigate the polarization effects for a range of wave-lengths which included the grating space. While the analogy of the slit is perhaps not a

[1] *Proceedings of the Royal Society* (A), **79**, 399, 1907.

[2] *Gött. Nachr. Math. Phys. Kl.* (1911), p. 40.

[3] *Ibid.*, **4**, 385, 1912.

[4] *Annalen der Physik*, **37**, 257, 1912.

[5] *Wiedemann's Annalen*, **13**, 133, 1881, and **15**, 587, 1882.

[6] *Philosophical Magazine* (6), **3**, 396, 1902, and **23**, 310, 1912. See also Rayleigh, *ibid.* (6), **14**, 60, 1907.

very good one, the fact that the theory of the transmission of radiation in this case breaks down for a wave-length equal to the width of the opening would seem to make it of interest to study gratings in this same spectral region.

Method and apparatus.—The apparatus[1] used was that developed by the writer in connection with preceding experiments[2] on various polarization phenomena in the early infra-red spectrum,

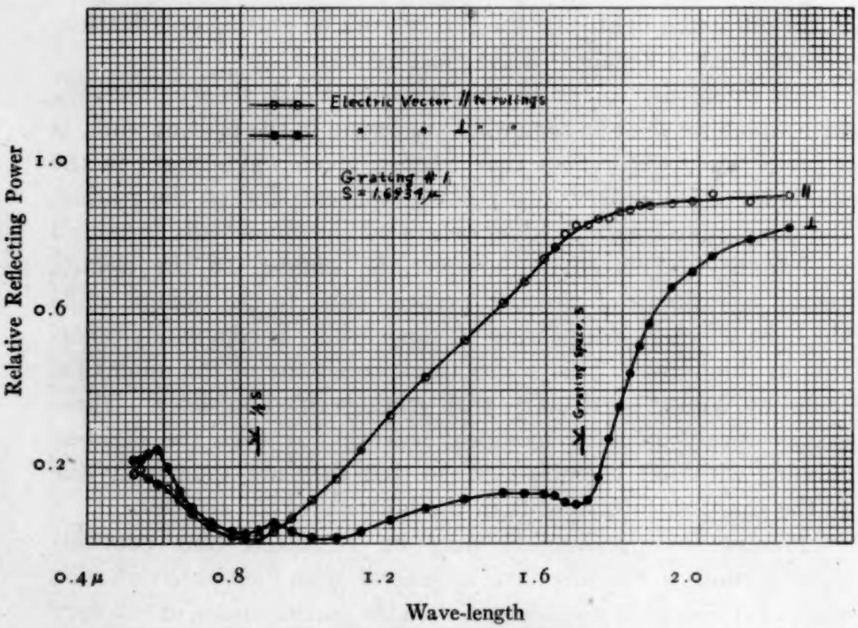

FIG. 1.—Reflection-curves for grating No. 1

although a somewhat simpler arrangement might have served equally well in the present investigation. Light from a flat filament tungsten lamp[3] was plane polarized at an angle of 45° with the vertical plane and allowed to fall on the grating, the incidence

[1] Acknowledgment is due the Rumford Fund for assistance in purchasing part of this apparatus some time ago.

[2] *Physical Review*, **35**, 312, 1912, and (2), **9**, 257, 1917; *Astrophysical Journal*, **32**, 265, 1910.

[3] These lamps were specially made and furnished through the courtesy of the Nela Research Laboratory.

being as nearly normal as possible. After reflection from the grating and then from a silver surface, also at nearly normal incidence, it passed through a large double-image prism whose planes of transmission were vertical and horizontal, respectively, and the two beams, after dispersion by a large mirror and prism spectrometer, fell on the two strips of a special bolometer already described in previous papers.[1] The grating was mounted in a holder which

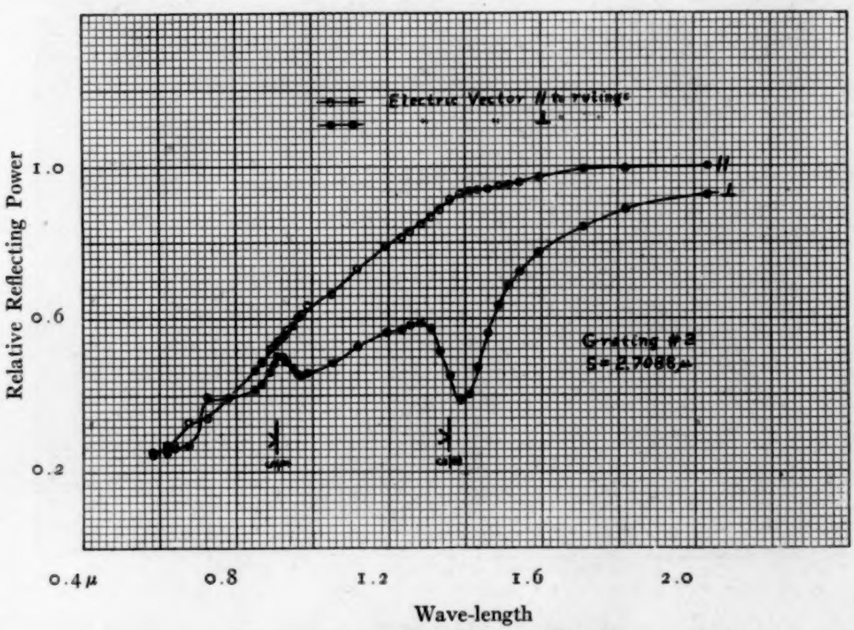

FIG. 2.—Reflection-curves for grating No. 2

allowed it to be shifted in the plane of the surface, so that the light could be alternately reflected from the ruled portion and from the polished unruled surface and the two intensities compared. The incidence obviously could not be made exactly normal, but the grating was set with the rulings parallel to the plane of incidence, save in a special case, which will be noted later, and the angle of incidence was always small—from 5° to 9°.

Measurements were made of the energy reflected from the ruled and unruled portions of the grating surface for both azimuths

[1] *Philosophical Magazine* (6), **18**, 74, 1909.

of polarization and for a series of wave-lengths from 0.5 μ to 2.3 μ. When the area of each part of the surface was sufficiently large the light was allowed to fall on the grating in a parallel beam. Otherwise it was converged to a focus near the grating surface, the cone of rays in this case subtending an angle of perhaps 3°. The phenomena observed were substantially the same in each case. The measurements in the present case were limited to the amplitude

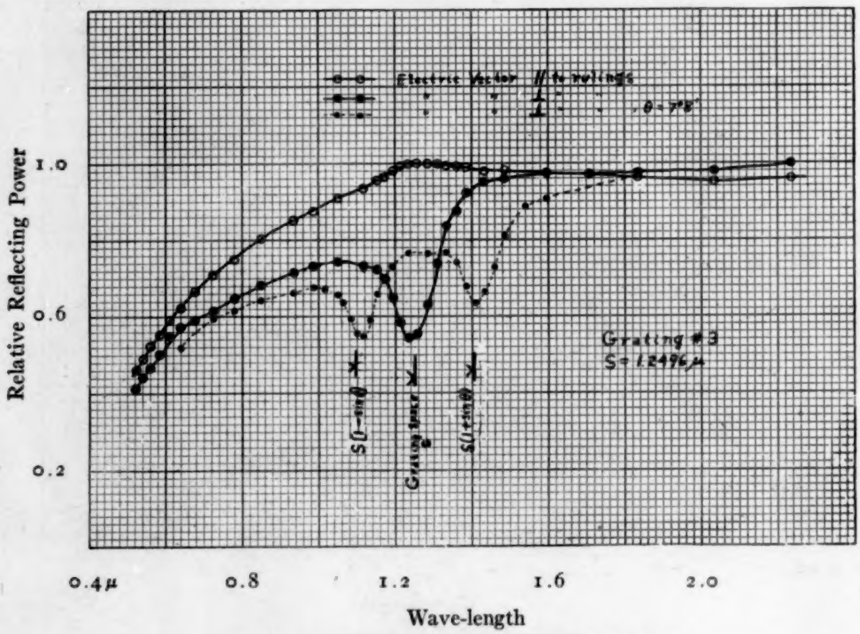

FIG. 3.—Reflection-curves for grating No. 3

(intensity) relation; the phase changes on reflection at such a surface are difficult to measure in this region of the spectrum, although the writer hopes to be able to accomplish this in a continuation of the present research.

Gratings.—Four plane reflecting gratings were tested in this way. They were:

1. A large Rowland grating of 15,000 lines to the inch—grating space $S = 0.0016934$ mm. This was loaned through the courtesy of Professor J. S. Ames. Part of the surface of this grating was

cross-ruled and not usable, but the remainder was ample in area for the purposes of this investigation. This grating showed a fairly bright first-order spectrum on one side and a very bright second-order spectrum on the same side. The central image was very faint.

2. A piece of Michelson grating of space 0.0027088 mm. This showed a bright first-order spectrum on one side as well as bright second- and third-order spectra.

3. A Michelson grating of space 0.0012496 mm. This showed bright first-order spectra, one slightly more intense than the other,

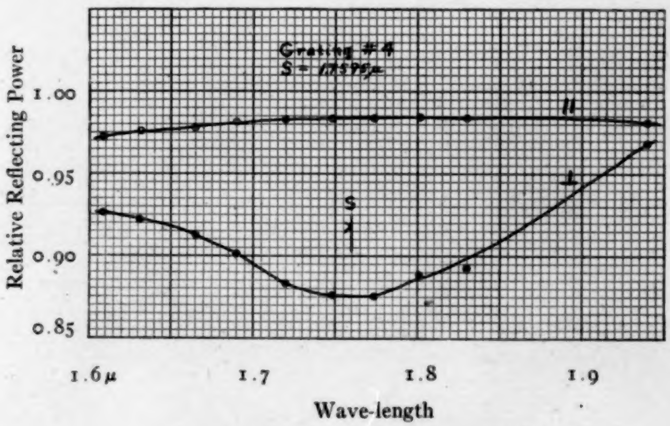

FIG. 4.—Reflection-curves for grating No. 4

and faint second-order spectra. For these last two gratings I am indebted to the kindness of Professor Gale.

4. A Rowland grating of space 0.0017595 mm, showing a bright first-order spectrum on one side. The second-order spectrum on this same side was extremely faint.

In all of the above-mentioned gratings the light diffracted tangentially showed a marked polarization with vibration perpendicular to the rulings, although this was somewhat less noticeable in grating No. 1 than in the three others.

Results.—These are shown in the curves of Figures 1–4, where the ratio of the energy reflected from the ruled surface divided by that from the unruled—i.e., the reflecting power of the ruled

relative to the polished surface—is plotted against wave-length for each azimuth of polarization. As might be expected, the curves all show an upward trend with increasing wave-length, and for wave-lengths longer than the grating space the reflecting power of the ruled portion is scarcely less than that of the unruled. This is reasonable, since in this case no energy can be dissipated in diffracted spectra.

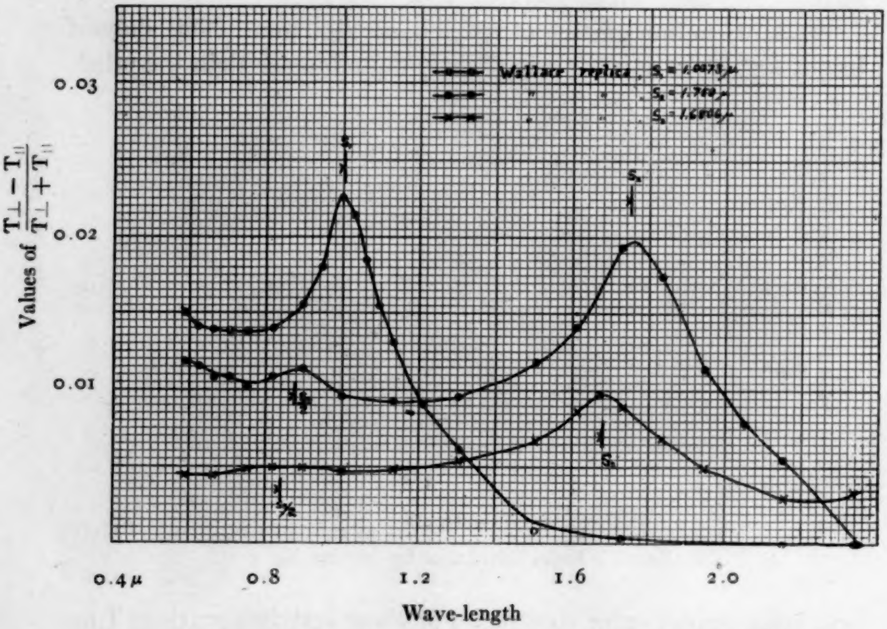

FIG. 5.—Curves showing polarization on transmission for three Wallace replica gratings.

The most striking thing about the curves, however, is the sharp minimum which occurs when the polarization (electric vector) is perpendicular to the rulings, for a wave-length equal to the grating space and in some cases for (approximately) one-half and one-third this value. For light at normal incidence and a wave-length equal to the grating space, the first-order spectrum is just disappearing tangentially from the grating. If we can assume, then, that there is a compensation whereby the excess of perpendicularly polarized energy which is coming off almost tangentially

is taken from the directly reflected light, we shall have an explanation of the foregoing effect. The same reasoning applies to the second-order spectra for a wave-length of half the grating space and a similar explanation holds for the third order. This is well illustrated by the curves of Figures 1–4. The agreement is not so good in the case of grating No. 2, but this was the least satisfactory one to work with, inasmuch as it was only a broken fragment with no unruled surface and the reflecting power had to be measured relative to another surface.

A rather critical test may be applied to the foregoing reasoning by tilting the grating slightly so that the angle of incidence—the grating now being turned so that the plane of incidence is normal to the rulings—is 6° or 8°. Under these conditions, then, the particular wave-length in the first-order spectrum on one side, which is just coming off tangentially, will be somewhat shorter than the grating space; while on the other side it will be a corresponding amount longer, the exact values being given by

$$\lambda_1 = S(1-\sin\theta) \text{ and } \lambda_2 = S(1+\sin\theta)$$

respectively. We should then expect to find the minimum at $\lambda = S$ in the perpendicular azimuth curve replaced by two somewhat smaller minima at these two wave-lengths. This experiment was tried for an angle of incidence of $\theta = 7°8'$, and the dotted curve of Figure 3 shows how well the foregoing prediction is justified. The slight difference in magnitude of the drop in the curve in the two minima probably indicates the relative energy in the two first-order spectra.

A point of some interest in this connection is that cleaning the gratings with ammonia, and even vigorous polishing (parallel to the rulings) with Vienna lime on chamois skin, failed to alter the phenomena in any material respect. It would seem, then, that this is a general characteristic of all gratings of this type, and is presumably dependent upon the form of the groove as a whole; that is to say, it is not determined merely by the thin edge of the ruling, as is probably the case in the silver grating experimented on by Wood. Such slight changes as were observed upon polishing were mostly confined to the visible spectrum, as might be expected.

It may be noted in this connection that, as shown by curves 1–3, the polarizing action of such gratings in the visible spectrum is a very variable quantity and dependent on the exact wave-length and particular grating tested. In the near infra-red, however, they would give in the central image, if illuminated with unpolarized light, an excess of radiation polarized parallel to the rulings. This is particularly true in the case of grating No. 1, where at $\lambda = 1.05\ \mu$ the reflected light would be 90 per cent polarized in this sense. Beyond $\lambda = S$ the polarizing action has largely disappeared.

Transmission gratings.—Some experiments were also tried on Wallace replica transmission gratings of 14,500 to 25,100 lines to the inch. These gratings show a slight polarization in the Hertzian sense, i.e., higher transmission for electric vector perpendicular to the rulings, but the effect is considerably smaller than for most reflection gratings. The measurements plotted in the curves of Figure 5 are not those of transmission through the ruled space of the grating relative to the unruled, but were obtained by simply rotating the grating in its plane through 90°. This gave at once the difference of the two transmissions divided by the sum, a quantity which is proportional to the percentage of polarized light which would be found in the directly transmitted beam if unpolarized light fell on the grating. The maxima at the grating space and half the grating space are very distinct, but experiments aimed at showing which vector was chiefly concerned in producing this maximum were rather unsatisfactory, although the weight of the evidence seemed to be in favor of the perpendicular vibration. As such gratings have somewhat less practical interest and have not been as carefully investigated theoretically as the others, this part of the subject has not been followed farther.

Conclusions.—The results of the present work show that the excess of perpendicularly polarized (electric vector) energy present in light tangentially diffracted from a reflecting grating is made up for by a deficiency in radiation of this polarization in the directly reflected beam. While not affording any direct proof[1] of the prediction of the Rayleigh-Voigt theory regarding abnormalities

[1] The writer hopes shortly to be able to investigate the polarization characteristics of the diffracted radiation in the near infra-red spectrum for a series of gratings.

in intensity of spectra of lower orders for this state of polarization, the deficiency in the central image noted above is more than sufficient to account for the energy for such abnormalities as well as for the effects found by Wood.[1]

From a practical standpoint, the evidence for the generality of such an effect as predicted by Raleigh and Voigt seems strong enough to make it advisable for observers of polarization phenomena, such as the Zeeman effect, to avoid it. This is easily done by keeping clear of such angles of incidence that the particular wave-length used is just passing from the grating in any higher order.

Physical Laboratory
University of Wisconsin
January 24, 1920

[1] *Philosophical Magazine* (6), 23, 314, 1912.

STUDIES BASED ON THE COLORS AND MAGNITUDES IN STELLAR CLUSTERS[1]

SIXTEENTH PAPER: PHOTOMETRIC CATALOGUE OF 848 STARS IN MESSIER 3

By HARLOW SHAPLEY and HELEN N. DAVIS

ABSTRACT

Globular cluster Messier 3.—The paper reports in detail measurements of 14 photographic plates taken at the primary focus of the 60-inch reflector during 1915 and 1917. Table II is a *photometric catalogue of 848 stars*, giving the photographic and photo-visual magnitudes and the color-index of each. Of these stars, 750 are suitable for statistical work. The known variables are omitted, but it appears from a comparison of the different plates that at least 17 others are probably *variable stars*. As for the *distribution of stars of various magnitudes and color-type*, a statistical study of the measurements shows that stars of all types and magnitudes are very well mixed, at least for angular distances from the center greater than 2′. The *spectral curve*, omitting variables, shows a maximum frequency near color-class *f*5 and differs from the corresponding curve for Messier 13 in being without a secondary maximum for the blue stars (Fig. 1). The *magnitude curve* shows a maximum frequency for photo-visual magnitude 15.5 which is near absolute magnitude zero, as computed on the basis of the previously determined *parallax* of 0″000072; the curve, as usual, is far from being symmetrical. The *relation of color-index to magnitude* shows the usual decrease of index with decreasing brightness (Fig. 3). In general these results corroborate those yielded by the previous analysis of Messier 13. The *position coordinates of 370 stars* which were not listed by von Zeipel are given in Table III.

An extended investigation of the photographic and photo-visual magnitudes of stars in the globular cluster Messier 13 is described in the second paper of this series, *Mt. Wilson Contr.* No. 116. The study yielded results of sufficient novelty and importance to justify the detailed corroborative analysis of another globular cluster. For this purpose the bright northern system Messier 3 was chosen because of the excellent catalogue of positions by von Zeipel[2] and the published and unpublished studies of variable stars at Harvard[3] and Mount Wilson.[4] The work was begun in

[1] *Contributions from the Mount Wilson Observatory*, No. 176.

[2] *Annales de l'Observatoire de Paris, Mémoires*, **25**, F1–101, 1908.

[3] *Harvard Annals*, **78**, 1–98, 1913.

[4] *Mt. Wilson Contr.*, No. 154, 1917; *Mt. Wilson Communications*, No. 47, 1917; *Publications of the Astronomical Society of the Pacific*, **29**, 110, 140, 1917.

1915 and completed nearly two years ago, some of the results appearing meanwhile in *Mt. Wilson Contr.* Nos. 151 and 152, and particularly in *Mt. Wilson Contr.* No. 155. An illustrated discussion of the dimensions of Messier 3 was printed in *Publications of the Astronomical Society of the Pacific*, **29**, 245, 1917.

Stars in the central part of Messier 3 have not been measured for magnitudes because of the uncertainties introduced by the Eberhard effect into photographic work in crowded regions. Between distances 1′.8 and 11′.3, however, the survey is practically complete to photo-visual magnitude 16.8, and about 140 fainter stars have also been measured. Altogether the catalogue contains 848 stars, less than 100 being within 2′ of the center.

The catalogue of Messier 13 (Table IX, *Mt. Wilson Contr.* No. 116) contains 616 stars, all more distant than 2′ from the center of the cluster, and complete to photo-visual magnitude 15.6, approximately. Because of the greater distance of Messier 3, the gain of 1.2 in apparent magnitude is partly lost when absolute magnitudes are considered. Thus, using the parallaxes given in *Mt. Wilson Contr.* No. 152, we have

	Messier 3	Messier 13
Parallax	0″.000072	0″.000090
m–M	15.72	15.23
Limit of Abs. Mag.	+1.08	+0.37

1. *Observational data.*—The photographs used in the present work are described in Table I. All were made at the primary focus of the 60-inch reflector. In addition to these plates more than eighty others have been made at Mount Wilson, largely for work on variable stars. The ten thousand measures of magnitude for the photometric catalogue are mainly the work of Miss Davis. Miss Ritchie has assisted in preparing the tables and figures for the press.

2. *Description of the catalogue.*—The numbers in the first column are those of von Zeipel's catalogue. Postscript letters are assigned to stars fainter than those listed by him. Miss Ritchie has measured position co-ordinates on photographic enlargements of the cluster for the identification of the 370 postscript stars,

referring each object to two or more stars of von Zeipel's catalogue. The results appear in Table III. The center of the cluster is

$$\left.\begin{array}{l}\text{R. A.} = 13^h37^m35^s \\ \text{Decl.} = +28°52'56''\end{array}\right\} 1900.0$$

according to the determination by von Zeipel. Approximate galactic co-ordinates are: Longitude = 8°, Latitude = +77°.

TABLE I

LIST OF PLATES

Plate		Date	Length of Exposure	No. Exposures on Pole	Use
Number	Kind				
2371...	Iso	1915, Apr. 16	10^m	2	Photo-visual magnitudes
2372...	S 27	Apr. 16	2	2	Comparison stars
2462...	Iso	June 7	10	1	Photo-visual magnitudes
2463...	S 27	June 7	3	2	Photographic magnitudes
2505...	Iso	July 6	20	1	Photo-visual magnitudes
2506...	S 27	July 6	3	2	Photographic magnitudes
3678...	Iso	1917, Mar. 28	5	2	Photo-visual zero point
3679...	S 27	Mar. 28	3	2	Photographic magnitudes
3680...	S 27	Mar. 28	2	2	Photographic magnitudes
3684...	Iso	Apr. 19	120, 20	0	Photo-visual magnitudes
3774...	Iso	May 27	52, 10	0	Photo-visual magnitudes
3775...	Iso	May 27	90, 15	0	Photo-visual magnitudes
3846...	S 27	July 25	4	2	Postscript stars, photographic
3847...	S 27	July 25	5	2	Postscript stars, photographic

An asterisk following the number in the first column indicates that the deduced magnitude is uncertain because of duplicity, bad image, or similar cause. Such stars are excluded from the statistical discussion. A dagger following the number indicates a comparison star used at Harvard and Mount Wilson for the study of variable stars. The magnitudes for these stars, collected in Table VI, depend upon a rather extensive discussion, which will be described in a later contribution dealing with the variables. The three stars marked with a double dagger, Nos. 612, 752, 982, were measured by Miss Ritchie after the completion of the catalogue and are not included in the following discussion; their spectra have been determined by Mr. Sanford and will be reported by him in another place.

[1] Corrections to von Zeipel's catalogue: No. 502 is about 10″ south of catalogued declination, which refers to our 502*a;* No. 1227 (on our chart made in 1915) is about 4″ north of the catalogued position; No. 184 is not found on Mount Wilson plates.

The second column contains the distance from the center of the cluster in minutes of arc. The final photographic and photo-visual magnitudes in the third and fifth columns, and the color-index in the last, are followed by colons when special uncertainty has affected the measurements; these doubtful results are also excluded from the statistical treatment. A few stars impossible of accurate measurement (brighter than photo-visual magnitude 17 and outside distance $1'.8$) may have been omitted entirely, but it is very unlikely that any of the omissions noted above have prejudiced the general interpretation of the observations.

For all determinations of a star's brightness the residuals from the mean are given in hundredths of a magnitude in the fourth and sixth columns of the catalogue. The photographic residuals refer, in order of the sub-column, to Plates 2463, 2506, 3679, and 3680, respectively, except that when in parentheses in the first two sub-columns the residuals refer to Plates 3846 and 3847. Similarly, the photo-visual residuals refer to Plates 2371, 2462, 2505, and 3684, respectively, with residuals for Plates 3774 and 3775 appearing in parentheses in the first two sub-columns. The letter "m" indicates that the tabulated magnitude depends upon only one plate. An asterisk following the photo-visual magnitude (six instances) means that the star was also measured on Plate 3678, but the residual for that plate is not entered in the following column; its value is the algebraic sum of the residuals there given with sign changed. Occasionally, in forming mean magnitudes, uncertain values were given half-weight; such cases are shown by the residuals; for example, see No. 926*a*.

To eliminate errors as far as possible, all color-indices less than -0.30 or greater than $+1.40$ have been independently redetermined from special series of measures, and all magnitude determinations showing residuals greater than 0.20 have been re-examined. Some corrections to the catalogue resulted from this supplementary work; its main outcome, however, is the conviction that many of the stars, whose magnitudes are similar to those of the variables, undergo slight variations of light. (Cf. discussion of their residuals in *Mt. Wilson Contr.* No. 155, p. 5.) The following

17 stars have photographic residuals greater than 0.25 and in most cases are probably variable stars:

251	845	1241
357	935	1244
603	962	1374
606	1146	1437
632	1170	1439
665	1214	

There are 49 stars, including the comparison star *h*, with photographic residuals between 0.20 and 0.25. All of these stars will be included in future investigations of the variables.

The photographic and photo-visual residuals are summarized for the principal plates in Tables IV and V.[1] The systematic errors are satisfactorily small and no serious divergence of scale has been found. The average probable error of the final magnitudes is ±0.04, which is of the same order of accuracy as that attained in the comparable study of Messier 13.

The contents of the catalogue (which does not include any of the 150 known variable stars) may be summarized as follows:

	Number of Stars
With asterisks	27
With no color-index	21
Color-index with colon (uncertain)	10
Fainter than 16.99 (Pv. mag.)	64
Supplementary	3
Suitable for statistical work (Tables VII, VIII, etc.)	750
Total	875
Subtract for duplicate listing	27
Net total in catalogue	848

3. *Statistical tables and diagrams.*—Tables VII and VIII are in the usual form for the correlation of magnitude, color, number, and distance. Tables IX and X give convenient summaries or rearrangements of the larger tables. From the various tables, and from the figures illustrating these tabular results, it is clear that distance from the center[2] plays no very important part in the

[1] Some stars were measured after the tables were formed, so that altogether more than 3600 residuals appear in the catalogue.

[2] This does not apply to distances less than 1'.5.

interrelations of color, magnitude, and number of stars. This conclusion supports the earlier one that the stars of all types and absolute magnitudes are very well mixed in a globular cluster.

The spectral curve of Messier 3 (Fig. 1) has its maximum near color-class *f*5, in that respect agreeing with Messier 13; but the form of the curve as it now stands differs conspicuously in the absence of a preliminary maximum for the blue stars. If colors for the 100 variables, within our present limits of distance from

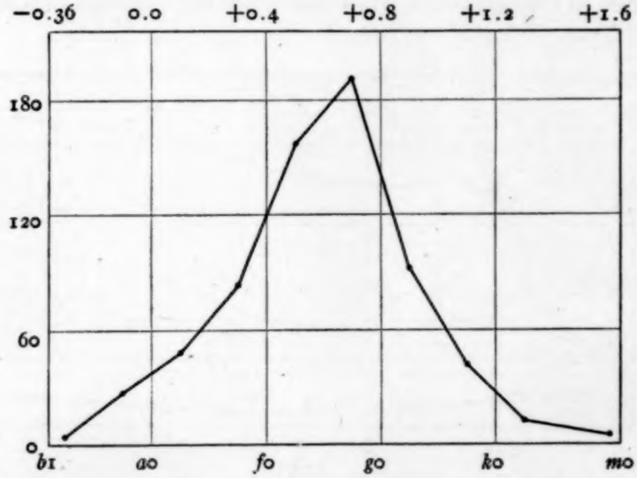

FIG. 1.—Spectral curve of giant stars in Messier 3; ordinates are numbers of stars in each half color-class; abscissae are color-indices and color-classes. Variable stars are not included; there are about 100 within the region studied, and their average median color-index, which varies with the light, is probably +0.25. (Cf. *Contribution*, No. 154, Fig. 4.)

the center, were also included in the diagram, it is probable that this dissimilarity between Messier 3 and Messier 13 would largely disappear. As noted before,[1] the many blue stars of Messier 13 appear to be represented in Messier 3 by cluster-type variables.

The photographic and photo-visual luminosity-curves for Messier 3 have been fully discussed in *Mt. Wilson Contr.* No. 155. The maximum frequency of stars in the vicinity of absolute magnitude zero is conspicuously shown, for all intervals of distance from the center, by the numbers in the last column of Table VIII. The

[1] *Mt. Wilson Contr.*, No. 155, p. 12, 1917.

wide divergence of these observed luminosity-curves from a symmetrical probability-curve again points to the inadvisability of assuming them comparable for the purpose of estimating the distances of clusters.[1]

Although the galactic latitude of Messier 3 is so high that superposed foreground stars are few, there may be some evidence in the shape of the curves in Fig. 2, of the influence of non-cluster stars on mean magnitude and color at distances greater than 7'. It is more likely, however, that the brighter average magnitudes

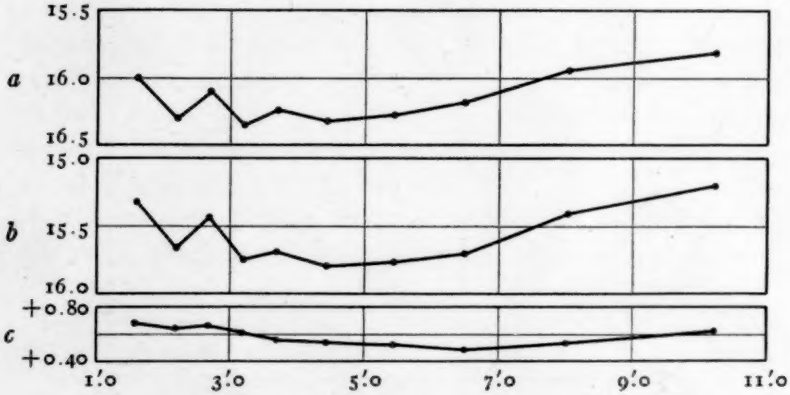

Fig. 2.—Average magnitudes and colors for different distances from the center: *a*) photographic magnitude; *b*) photo-visual magnitude; *c*) color-index. Abscissae are distances in minutes of arc.

at the greatest distances, and also near the center, are due to incompleteness of the catalogue to the seventeenth photo-visual magnitude in those regions.

Figure 3*a* illustrates for Messier 3 the decrease of color-index with decreasing brightness, which has been found to be a typical characteristic of the giant stars in globular clusters. A similar diagram for Messier 13 based on data given in *Mt. Wilson Contr.* No. 116 is given in Fig. 3*b*. In both cases the mean absolute magnitudes are derived from the parallaxes given earlier in this paper.

[1] Cf. *Mt. Wilson Contr.*, No. 175, 1919.

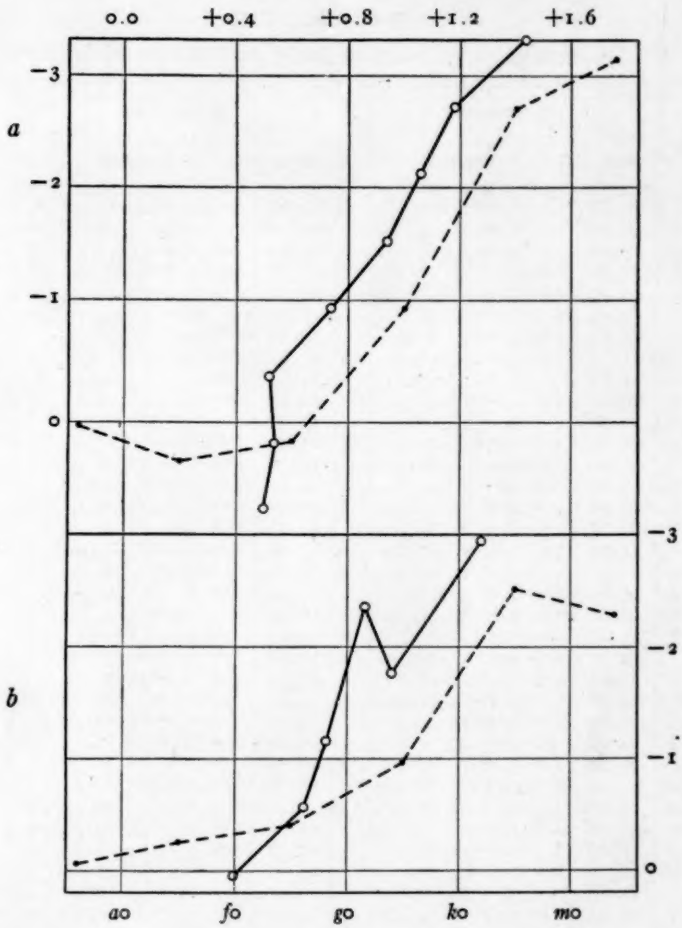

FIG. 3, *a* and *b*

a) The color of giant stars in Messier 3 (distance ⋚ 2′). The circles indicate the mean color-index for equal intervals of magnitude (Table X); the dots indicate mean magnitudes for equal intervals of color-index (Table IX). Abscissae are color-classes and color-indices; ordinates are absolute photo-visual magnitudes. The form of the broken curve is of course affected by the absence from the catalogue of stars fainter than photo-visual magnitude 17. The continuous curve, however, accurately represents the change of average color with brightness down to photo-visual magnitude 16.8; fainter stars are not included.

b) Similar representation of the color of giant stars in Messier 13 (distance ⋚ 2′ except for *m* stars).

TABLE II

PHOTOMETRIC CATALOGUE OF 848 STARS IN MESSIER 3

Number	Distance	Photographic		Photo-visual		Color-Index
		Mag.	Residuals	Mag.	Residuals	
145...	11′.4	15.84	+ 8,− 7,....,....	16.02	(−15,+14)....,....	−0.18
155...	9.8	15.12	− 4,+ 5,....,....	14.52	....,...., m,....	+0.60
157...	9.7	15.48	− 9,+ 8,....,....	15.52	(+ 6,− 5)....,....	−0.04
157*a*..	9.8	17.17	(+ 4,− 4)....,....	16.68	(−11,+10)....,....	+0.49
157*b*..	8.9	16.18	(+ 2,− 1)....,....	15.42	(0, 0)....,....	+0.76
157*c*..	8.9	17.42	(...., m)....,....	16.39	(m,....)....,....	+1.03
158...	9.8	15.82	+ 4,− 5,....,....	15.37	(− 5,+ 5)....,....	+0.45
162...	9.2	15.10	+ 5,− 1,− 3,....	14.63	(....,− 2)+ 2,....	+0.47
164...	9.0	14.54	+ 7,+ 7,−13,....	13.62	0,...., 0,....	+0.92
164*a*..	8.8	16.71	(+ 1,− 1)....,....	16.16	(− 4,+ 4)....,....	+0.55
164*b*..	9.2	16.78	(− 6,+ 7)....,....	16.16	(...., m)....,....	+0.62
164*c*..	9.4	16.82	(− 6,+ 7)....,....	16.12	(+ 6,− 6)....,....	+0.70
166...	9.0	16.00	− 2,+ 4,− 2,....	15.30	(− 3,+ 3)....,....	+0.70
167...	8.4	15.68	+ 2,− 3,....,....	14.97	(+ 3,− 3)....,....	+0.71
168...	9.4	16.36	− 4,+ 5,....,....	15.62	(+ 2,− 1)....,....	+0.74
168*a*..	9.1	16.78	(+ 1,− 1)....,....	16.06	(− 6,+ 7)....,....	+0.72
169...	9.6	14.90	+ 1,− 1,....,....	13.86	(+19,−20)....,....	+1.04
174...	13.0	.....	....,....,....,....	11.11:	m,....,....,....	.....
175...	8.4	15.85	− 9,+ 5,+ 3,....	15.36	(− 1, 0)....,....	+0.49
175*a*..	8.6	16.94	(+ 6,− 5)....,....	16.64	(−11,+11)....,....	+0.30
177...	7.8	14.45	− 8,+11,− 2,....	13.45	+ 5,....,− 5,....	+1.00
177*a*	7.4	16.19	(− 1,+ 1)....,....	15.58	(+ 3, −2)....,....	+0.61
177*b*..	6.9	17.13	(+12,−12)....,....	16.72	(− 2,+ 3)....,....	+0.41
179...	7.6	14.98	0,− 1,....,....	14.53	....,...., m,....	+0.45
179*a*..	7.3	16.74	(− 2,+ 3)....,....	16.30	(0,− 1)....,....	+0.44
180...	9.3	16.08	+ 4,− 4,....,....	15.03	(0, 0)....,....	+1.05
180*a*..	11.0	16.80	(+ 6,− 7)....,....	16.50	(− 7,+ 8)....,....	+0.30
180*b*..	10.6	16.94	(− 1,+ 2)....,....	15.76	(−12,+11)....,....	+1.18
181*a*..	7.4	17.02	(+ 8,− 9)....,....	.....	....,....,....,....	.....
181*b*..	7.9	16.68	(+ 2,− 2)....,....	16.18	(− 6,+ 5)....,....	+0.50
181*c*..	8.2	17.08	(0,+ 1)....,....	16.58	(+ 3,+ 4)....,....	+0.50
182...	10.2	15.39	−17,+17,....,....	15.42	(0, 0)....,....	−0.03
187...	9.1	15.80	+ 3,− 3,....,....	15.00	(− 2,+ 3)....,....	+0.80
188...	7.2	15.12	− 1,+ 1,....,....	14.55	....,...., m,....	+0.57
188*a*	7.0	16.92	(0,+ 1)....,....	16.60	(−10,+ 9)....,....	+0.32
188*b*..	7.8	16.80	(− 1,+ 1)....,....	16.33	(+13,−13)....,....	+0.47
188*c*..	6.7	17.18	(+ 6,− 5)....,....	16.74	(− 4,+ 4)....,....	+0.44
188*d*..	6.3	16.36	(− 6,+ 5)....,....	15.68	(+ 4,− 4)....,....	+0.68
189...	6.5	15.92	+ 3,− 2,...., 0	15.24	(+11,−10)....,....	+0.68
190...	6.6	15.57	− 3,+ 8,....,− 6	15.42	(− 5,+ 5)....,....	+0.15
190*a*..	6.5	17.16	(− 2,+ 1)....,....	16.56	(− 3,+ 4)....,....	+0.60
191...	8.5	15.49	+ 9,+12,−14,− 8	15.40	(− 3,+ 2)....,....	+0.09
192...	6.2	14.65	+10,− 4,− 1,− 4	13.80	....,− 2,+ 1,....	+0.85
193...	9.6	15.36	−14,+15,....,....	14.54	....,+ 3,− 2,....	+0.82
193*a*..	9.3	16.64	(− 2,+ 2)....,....	16.06	(− 3,+ 4)....,....	+0.58
194...	7.0	14.59	− 2,+18,−10,− 5	13.64	− 1,− 5,+ 5,....	+0.95
195...	8.8	16.20	− 5,+ 6,....,....	15.80	(−13,+13)....,....	+0.40
196...	8.0	15.49	− 6,+12,− 5,− 1	15.40	(+ 5,+ 7)....,−11	+0.09
198...	7.6	16.42	+ 5,− 5,....,....	15.73	(− 6,+ 6)....,....	+0.69
199...	6.0	15.50	0,+11,−13,+ 4	14.78	(− 1,+ 1)........,	+0.72

TABLE II—*Continued*

Number	Distance	Photographic Mag.	Photographic Residuals	Photo-visual Mag.	Photo-visual Residuals	Color Index
200...	7′.1	15.68	− 1,− 3,+15,−10	14.87	(....,+13)−13,....	+0.81
202...	6.0	15.61	+ 6,+12,− 6,−13	15.34	(− 2,+ 2)....,....	+0.27
203...	7.0	15.45	+ 1,+20,−24,+ 3	15.37	(+ 5,+ 8)....,−14	+0.08
204...	7.7	15.71	+21,− 2,− 3,−16	15.74	(− 7,+ 7)....,....	−0.03
205...	6.2	13.81	− 3,−23,+20,+ 6	12.72*	+ 2,− 2,− 9,....	+1.09
205*a*..	6.0	16.78	(− 2,+ 3)....,....	16.10	(−13,+13)....,....	+0.68
206...	7.4	11.27	....,− 2,....,+ 2	10.26*	+ 7,− 3,− 6,....	+1.01
206*a*..	7.5	16.90	(−11,+11)....,....	16.26	(+ 1, 0)....,....	+0.64
208...	8.2	16.76	− 1,+ 1,....,....	16.22	(− 4,+ 4)....,....	+0.54
208*a**.	8.3	17:25	(m,....)....,....	16.65:	(m,....)....,....	+0.60:
210...	5.5	15.40	− 1,+11,−19,+11	15.53	(0, 0)....,....	−0.13
210*a*..	5.7	16.82	(− 3,+ 3)....,....	15.96	(−15,+14)....,....	+0.86
210*b*..	5.7	17.28	(− 3,+ 2)....,....	16.64	(+ 1,− 1)....,....	+0.64
211...	5.5	15.86	+18,+ 4,....,−21	15.33	(− 6,+ 3)....,+ 4	+0.53
211*a*..	5.5	16.06	(− 8,+ 8)....,....	15.26	(− 9,+10)....,....	+0.80
211*b*..	5.2	17.27	(+ 1,− 1)....,....	16.74	(− 9,+10)....,....	+0.53
212...	6.3	16.15	+ 5,+ 3,−10,+ 1	15.40	(+ 5,− 4)....,....	+0.75
212*a*..	5.8	17.28	(− 3,+ 2)....,....	16.88	(0, 0)....,....	+0.40
212*b*..	6.3	17.36	(−18,+18)....,....	16.76	(−15,+15)....,....	+0.60
213...	7.1	15.48	+ 9,+ 8,−18,+ 3	15.44	(+ 3,+ 6)....,−10	+0.04
215...	5.4	16.74	− 2,+ 1,....,....	16.25	(+ 2,− 2)....,....	+0.49
215*a*..	5.4	17.42	(...., m)....,....	16.61	(m,....)....,....	+0.81
216...	9.1	14.77	+14,+ 8,−10,−12	13.83	0,− 2,+ 1,....	+0.94
217...	5.7	16.25	+ 2,+ 5,....,− 7	15.64	(+ 5,− 5)....,....	+0.61
218†..	5.7	15.04	− 2,+ 1,− 2,+ 3	14.51	....,+ 9,− 9,....	+0.53
219...	7.2	16.02	+10,−12,+ 3, 0	15.15	(− 7,+ 7)....,− 1	+0.87
220...	8.2	16.46	+ 6,− 5,....,....	15.71	(− 2,+ 2)....,....	+0.75
225...	5.2	15.62	− 8,+20,− 7,− 4	14.74	....,...., m,....	+0.88
227†..	5.0	15.25	− 1,− 9,− 2,+10	14.60	....,− 8,+ 9,....	+0.65
228...	10.0	15.78	−11,+12,....,....	15.10	(− 5,+ 5)....,....	+0.68
229...	5.8	15.30	−11,+ 8,− 9,+11	14.58	....,...., m,....	+0.72
230...	9.0	15.74	− 4,+ 3,....,....	15.34	(− 7,+ 8)....,....	+0.40
230*a*..	9.3	16.56	(+ 6,− 6)....,....	15.66	(+ 1,− 2)....,....	+0.90
230*b*..	9.6	17.19	(+ 2,− 2)....,....	16.72	(...., m)....,....	+0.47
230*c*..	10.0	16.60	(+ 6,− 7)....,....	16.03	(0, 0)....,....	+0.57
231...	5.5	15.43	0,+18,−18,....	14.78	....,−11,....,+11	+0.65
232...	8.7	15.87	+ 5,− 5,....,....	15.22	(+ 3,− 2)....,....	+0.65
233...	6.4	16.78	+ 2,− 3,....,....	16.11	(− 5,+ 5)....,....	+0.67
235...	7.5	15.53	+21,− 2,−12,− 6	15.50	(+ 3,− 3)....,....	+0.03
236...	5.3	15.87	−10,+ 8,+ 1,+ 1	15.36	(− 4,− 3)....,+ 8	+0.51
237...	6.6	14.33	−15,−10,+10,+16	13.91	+10,− 6,− 3,....	+0.42
238†..	4.5	14.27	−16,+ 3,....,+12	12.48*	+14,....,+ 6,....	+1.79
238*a*..	4.3	16.82	(−12,+11)....,....	16.16	(− 4,+ 4)....,....	+0.66
238*b*..	4.5	16.72	(0,+ 1)....,....	16.22	(− 1,+ 2)....,....	+0.50
240...	4.7	15.34	+ 9,+ 9,−19,+ 1	14.68	....,+14,−13,....	+0.66
241...	5.6	15.55	−20,+18,....,+ 3	15.18	(−10,+10)....,....	+0.37
245...	4.6	15.65	+ 2,+ 8,− 7,− 4	15.63	(+15,+10)....,−24	+0.02
247...	4.2	15.74	+ 2,+12,....,−13	15.43	(− 8,+ 7)...., 0	+0.31
247*a*..	4.0	16.76	(−29,+29)....,....	16.50	(+ 3,− 4)....,....	+0.26
248...	5.4	15.86	+ 6,+ 4,−11,....	15.54	(+ 1,− 1)....,....	+0.32
249*a*..	5.0	17.36	(− 5,+ 6)....,....	16.99	(−11,+11)....,....	+0.37
249*b*..	5.1	16.99	(− 2,+ 2)....,....	16.41	(+ 9,− 9)....,....	+0.58

TABLE II—*Continued*

Number	Distance	Photographic		Photo-visual		Color-Index
		Mag.	Residuals	Mag.	Residuals	
250†..	5′.2	14.81	+ 4,+ 7,− 5,− 6	13.91	− 1, 0,+ 2,....	+0.90
250*a*..	5.4	16.78	(+ 1,− 1)....,....	16.22	(+ 5,− 6)....,....	+0.56
251...	4.4	15.78	+32,− 5,−10,−17	14.89	....,− 9,−10,.... (+19,....)	+0.89
251*a*..	4.3	17.09	(−12,+12)....,....	16.60	(+15,−14)....,....	+0.49
253*a*..	5.2	16.76	(0,+ 1)....,....	16.17	(+ 1,− 1)....,....	+0.59
255...	5.6	15.11	− 7,− 6,....,+13	14.11	− 6,+10,− 4,....	+1.00
255*a*..	5.5	17.16	(+ 2,− 3)....,....	16.63	(− 6,+ 6)....,....	+0.53
256...	9.7	16.07	+ 3,− 3,....,....	14.98	(0,− 1)....,....	+1.09
257...	4.7	16.21	− 4,+ 5,...., 0	15.60	(+ 1,− 1)....,....	+0.61
258†..	4.3	15.52	+15,+ 6,....,−21	15.54	(− 4,+ 5)....,....	−0.02
258*a*..	4.1	17.27	(−19,+19)....,....	16.84	(+ 4,− 3)....,....	+0.43
259...	3.9	15.82	+ 4,+13,....,−17	15.46	(+ 4,− 4)....,....	+0.36
260...	3.9	16.59	− 7,+ 7,....,....	15.75	(− 6,+ 6)....,....	+0.84
260*a*..	3.7	17.32	(+ 3,− 2)....,....	16.97	(−13,+13)....,....	+0.35
261...	5.7	15.90	+ 8,− 8,....,....	15.30	(− 3,+ 3)....,....	+0.60
261*a*..	6.1	17.17	(− 9,+ 9)....,....	16.74	(− 4,+ 4)....,....	+0.43
262...	4.5	15.84	− 1,+ 2,....,....	15.33	(+12,+ 6)....,−17	+0.51
262*a*..	4.8	16.76	(− 6,+ 5)....,....	16.19	(− 1,+ 1)....,....	+0.57
263†..	4.1	14.53	+ 7,−10,− 7,+11	13.41	−10,+ 7,+ 2,....	+1.12
265...	5.0	14.29	−22,+18,+ 4,....	13.15	− 5,+ 3,+ 3,....	+1.14
266...	5.1	16.22	+ 3,− 4,....,....	15.61	(+ 3,− 8)....,....	+0.61
268...	5.7	16.34	− 2,− 4,....,+ 7	15.60	(+ 4,− 4)....,....	+0.74
270...	3.9	16.16	+ 9,− 8,....,....	15.29	(− 4,+ 4)....,....	+0.87
272...	5.1	16.56	− 2,+ 1,....,....	15.84	(− 3,+ 3)....,....	+0.72
273...	3.7	16.00	− 8,+ 4,....,+ 5	15.22	(− 7,+11)....,− 5	+0.78
276...	3.5	16.24	+ 8,− 6,....,+ 1	16.42	(− 6,+ 7)....,....	−0.18
277...	3.6	15.17	− 2,− 4,....,+ 7	14.55	....,...., m,....	+0.62
280*..	4.2	.....	....,....,....,....	17.41	(...., m)....,....	......
281...	4.8	14.61	− 4,+ 4,...., 0	13.42	− 6,+ 6,+ 1,....	+1.19
281*a*..	4.5	17.01	(...., m)....,....	16.98	(+18,−17)....,....	+0.03
282...	4.1	15.90	+ 5,− 4,....,....	14.99	(+11,− 5)....,− 6	+0.91
283...	3.3	16.55	− 8,+ 5,....,+ 2	15.92	(− 2,+ 1)....,....	+0.63
285...	3.3	16.59	+ 8,+ 4,....,−13	16.05	(− 5,+ 5)....,....	+0.54
286...	3.2	15.77	− 1,+ 9,....,− 9	15.11	(− 1,+ 1)....,....	+0.66
289...	3.3	15.24	+ 5,−11,....,+ 7	14.40	....,.... m,....	+0.84
290...	8.0	15.74	−11,+ 8,− 2,+ 4	15.41	(− 4,+ 4)....,....	+0.33
290*a*..	8.0	17.12	(− 4,+ 5)....,....	16.84	(−19,+19)....,....	+0.28
290*b*..	8.0	16.98	(+10,−10)....,....	16.46	(−10,+10)....,....	+0.52
291...	3.1	14.85	+16,− 8,....,− 9	14.06	+ 4,− 3,− 1,....	+0.79
291*a*..	3.0	17.02	(− 2,+ 3)....,....	16.32	(− 2,+ 3)....,....	+0.70
291*b*..	3.4	17.30	(− 5,+ 4)....,....	16.76	(+12,−11)....,....	+0.54
291*c*..	3.7	17.26	(− 5,+ 4)....,....	16.90	(− 6,+ 5)....,....	+0.36
292...	3.5	15.60	0,+13,−12,....	15.58	(0,+ 1)....,....	+0.02
293...	3.1	15.50	+ 4,− 3,....,....	14.61	....,....,+ 5,− 5	+0.89
296*a*..	3.2	17.42	(− 4,+ 4)....,....	17.11	(−23,+23)....,....	+0.31
296*b*..	3.4	17.38	(− 3,+ 4)....,....	17.17	(...., m)....,....	+0.21
297...	7.4	14.14	−13,+17,− 3,....	12.82	0,−12,+11,....	+1.32
298...	4.2	16.50	0,+ 1,....,....	15.78	(− 6,+ 6)....,....	+0.72
299...	7.0	16.14	+ 3,− 3,....,− 1	15.38	(− 6,+ 7)....,....	+0.76
300...	3.0	16.64	+ 2,− 1,....,....	15.90	(− 6,+ 6)....,....	+0.74
301...	4.5	15.85	+10,+10,....,−20	15.42	(−10,+11)....,− 2	+0.43
301*a*..	4.5	17.16	(+12,−11)....,....	16.62	(+ 3,− 4)....,....	+0.54

TABLE II—*Continued*

Number	Distance	Photographic Mag.	Photographic Residuals	Photo-visual Mag.	Photo-visual Residuals	Color-Index
301*b*..	4′.8	16.68	(− 6,+ 5)....,....	15.94	(−13,+12)....,....	+0.74
301*c*..	5.2	17.13	(−13,+13)....,....	16.78	(+ 6,− 6)....,....	+0.35
301*d*..	5.3	17.24	(− 6,+ 6)....,....	17.14	(...., m)....,....	+0.10
302*..	3.4	14.95	m,....,....,....	.....	....,....,....,....	......
303...	2.8	16.51	+ 3,+ 3,....,− 7	15.82	(+ 8,− 9)....,....	+0.69
303*a*..	2.9	17.02	(− 2,+ 3)....,....	16.42	(− 3,+ 4)....,....	+0.60
304...	2.8	15.49	+14,+ 2,−17,....	15.53	(− 3,+ 3)....,....	−0.04
305*a*..	4.6	17.16	(− 2,+ 1)....,....	16.46	(m,....)....,....	+0.70
306...	2.7	16.12	− 5,− 1,+ 5,....	15.22	(0, 0)....,....	+0.90
307...	3.8	15.96	− 4,+12,− 8,....	15.16	(− 1,+ 1)....,....	+0.80
307*a*..	3.9	16.70	(+ 9,− 8)....,....	16.06	(−13,+14)....,....	+0.64
307*b*..	4.1	16.96	(+ 4,− 3)....,....	16.58	(−12,+11)....,....	+0.38
308...	3.0	15.80	+15,−15,....,....	15.66	(+ 6,− 5)....,....	+0.14
308*a*..	2.7	16.60	(−17,+17)....,....	15.88	(+ 5,− 4)....,....	+0.72
308*b*..	3.4	17.22	(+16,−17)....,....	17.02	(−14,+15)....,....	+0.20
309...	2.7	14.37	−24,+ 6,....,+17	13.18*	−12,+ 7,−11,....	+1.19
310...	2.8	16.92	+ 3,− 4,....,....	15.78	(− 6,+ 6)....,....	+1.14
310*a*..	2.8	17.22	(−12,+12)....,....	16.74	(+ 5,− 5)....,....	+0.48
311...	3.6	15.45	+ 1,+20,−20,....	15.52	(+ 3,− 2)....,....	−0.07
311*a*..	3.5	16.82	(0,− 1)....,....	16.02	(− 9,+ 8)....,....	+0.80
311*b*..	3.4	17.08	(− 4,+ 5)....,....	16.51	(+ 2,− 2)....,....	+0.57
312...	2.7	15.98	+ 3,+ 6,−10,....	14.97	(+ 6,− 6)....,....	+1.01
313...	2.7	16.59	− 7,+ 7,....,....	15.84	(+ 6,− 5)....,....	+0.75
314...	4.8	15.34	+ 1,+22,−22,....	14.40	....,...., m,....	+0.94
315...	3.3	15.49	+11,+12,−24,....	14.77	....,...., m,....	+0.72
317...	3.0	15.92	+15,−15,....,....	15.90	(0, 0)....,....	+0.02
319...	3.6	16.48	− 6,+ 6,....,....	15.73	(+14,−14)....,....	+0.75
320...	6.3	16.66	−10,+ 9,....,....	15.95	(+ 8,− 8)....,....	+0.71
320*a*..	6.3	17.24	(− 3,+ 2)....,....	16.72	(−15,+16)....,....	+0.52
320*b*..	6.2	16.98	(+ 6,− 5)....,....	16.68	(− 3,+ 4)....,....	+0.30
322...	2.9	17.04	− 9,+10,....,....	16.65	(− 4,+ 4)....,....	+0.39
322*a*..	2.9	17.38	(− 7,+ 8)....,....	16.76	(− 1,+ 2)....,....	+0.62
323...	2.7	15.35	+ 8,−14,....,+ 6	14.39	...., 0, 0,....	+0.96
325...	3.8	15.98	+ 3,+13,−15,....	15.40	(+ 7,− 7)....,....	+0.58
326...	2.8	15.64	− 1,+ 5,....,− 3	14.68	....,−11,+11,....	+0.96
326*a*..	3.0	17.30	(− 5,+ 4)....,....	16.77	(− 7,+ 7)....,....	+0.53
326*b*..	3.0	17.26	(...., m)....,....	16.57	(m,....)....,....	+0.69
326*c*..	3.2	17.08	(+13,−12)....,....	16.20	(− 2,+ 3)....,....	+0.88
327...	3.2	15.82	+ 1,+ 8,....,−10	15.44	(−12,− 2)....,+15	+0.38
329...	4.4	15.93	−10,+11,− 2,....	15.12	(− 2,+ 2)....,....	+0.81
330...	2.5	16.39	− 7,+ 2,....,+ 5	15.62	(+ 2,− 1)....,....	+0.77
331...	6.2	15.45	− 6,+16,....,−10	15.40	(− 5,+ 5)....,....	+0.05
332...	3.9	15.85	− 6,+ 5,+ 1,....	15.26	(− 9,+ 7)....,+ 3	+0.59
332*a*..	4.1	17.26	(− 5,+ 4)....,....	16.82	(−17,+17)....,....	+0.44
332*b*..	3.9	17.34	(− 3,+ 3)....,....	16.86	(− 2,+ 2)....,....	+0.48
334...	2.6	14.27	−14,+12,+ 1,....	13.14	− 2,+15,−13,....	+1.13
335...	3.6	16.10	+ 7,+ 5,− 2,− 8	15.44	(− 9,+10)....,....	+0.66
336...	2.9	15.07	+ 4,+ 2,− 6,....	14.05	+13,− 7,− 6,....	+1.02
336*a*..	3.0	17.17	(+ 4,− 4)....,....	.....	....,....,....,....	......
337...	2.4	15.54	+19,− 3,−22,+ 7	15.60	(+ 1,− 1)....,....	−0.06
339...	2.9	15.49	−17,+24,....,− 8	14.76	....,....,+ 5,− 6	+0.73
340...	2.7	16.65	−15,+15,....,....	15.88	(− 1,+ 2)....,....	+0.77

TABLE II—*Continued*

Number	Distance	Photographic		Photo-visual		Color-Index
		Mag.	Residuals	Mag.	Residuals	
341	3′.5	15.55	−12,+22,....,−10	14.69	....,...., m,....	+0.86
342	5.5	15.75	+ 4,+ 7,....,−10	15.40	(− 3,+ 2)....,....	+0.35
343	2.6	15.40	+ 6,− 6,....,+ 1	15.26	(−11,+ 7)....,+ 3	+0.14
345	3.0	14.61	− 4,+ 8,− 5,....	13.35	+ 2,+ 2,− 4,....	+1.26
345*a*	3.1	17.30	(−12,+12)....,....	16.78	(+10,−11)....,....	+0.52
347	2.8	16.13	− 1,+ 2, 0,....	15.42	(− 7,+ 8)....,....	+0.71
348	2.3	14.76	− 4,+ 1,....,+ 4	13.88	+10,− 2,− 8,....	+0.88
348*a*	2.2	16.76	(+ 3,− 3)....,....	16.14	(− 5,+ 6)....,....	+0.62
349	3.6	15.89	+21,− 7,−14,....	14.96	(+12,−11)....,....	+0.93
350	3.0	16.46	−16,+17,....,....	15.60	(+ 1,+ 1)....,− 3	+0.86
350*a*	2.9	17.36	(− 1,+ 1)....,....	16.76	(− 6,+ 5)....,....	+0.60
352	2.3	15.24	+ 1,−11,....,+11	14.28	− 6,+ 2,+ 5,....	+0.96
354	6.5	15.76	+ 3,− 3,....,....	15.47	(m,....)....,....	+0.29
355*a*	2.4	16.87	(+10,−10)....,....	16.24	(− 3,+ 2)....,....	+0.63
357	2.4	15.20	+26,+14,−40,....	14.45	(− 3,+ 3)....,....	+0.75
360	2.1	15.82	− 3,+17,....,−14	15.02	(+ 6,− 5)....,....	+0.80
360*a*	2.1	16.03	(+ 2,− 2)....,....	15.50	(− 3,+ 3)....,....	+0.53
360*b*	2.1	16.93	(0, 0)....,....	16.19	(− 7,+ 7)....,....	+0.74
360*c*	2.1	17.10	(0,− 1)....,....	16.52	(+ 9,− 8)....,....	+0.58
360*d*	2.2	17.46	(− 8,+ 8)....,....	16.89	(−10,+10)....,....	+0.57
364	2.1	15.75	−21,+24,....,− 3	15.78	(+ 9,− 8)....,....	−0.03
364*a*	2.1	16.84	(+ 2,− 3)....,....	15.90	(+ 3,− 3)....,....	+0.94
365	2.1	15.62	+ 8,+ 3,−11,....	15.54	(+ 4,− 4)....,....	+0.08
367	2.3	15.10	+ 5,+ 3,− 9,....	13.96	− 6,+ 2,+ 3,....	+1.14
369	2.0	15.08	+ 3,+ 5,− 9,....	14.40	....,...., m,....	+0.68
370	1.9	16.85	−13,+13,....,....	16.24	(0,− 1)....,....	+0.61
371	6.6	15.11	+ 4,−10,− 7,+13	14.81	(− 1,+ 1)....,....	+0.30
372	2.5	15.63	+ 4,+ 6,....,− 9	14.71	....,...., m,....	+0.92
373	2.3	16.22	−15,+15,....,....	15.46	(+12,−13)....,....	+0.76
375	1.9	15.49	+11,+ 7,−19,....	14.77	....,...., m,....	+0.72
376	1.9	16.06	− 2,+ 2,....,....	15.41	(− 1,+ 1)....,....	+0.65
376*a*	1.9	16.80	(− 4,+ 5)....,....	16.32	(...., m)....,....	+0.48
377	2.1	15.92	+12,+ 7,−20,....	15.26	(+ 1,− 1)....,....	+0.66
378*a*	4.0	17.40	(− 2,+ 2)....,....	16.99	(−15,+15)....,....	+0.41
379*a*	2.4	17.45	(− 7,+ 7)....,....	16.96	(+ 8,− 8)....,....	+0.49
379*c*	2.4	17.34	(...., m)....,....	16.58	(+ 8,− 8)....,....	+0.76
380	1.9	16.05	− 1,+10,....,−10	15.24	(− 7,+ 6)....,....	+0.81
380*a*	2.1	16.88	(+ 2,− 3)....,....	16.08	(−11,+12)....,....	+0.80
380*b*	2.2	17.34	(+ 1, 0)....,....	16.98	(− 5,+ 5)....,....	+0.36
381	2.1	15.22	+ 7,− 9,....,+ 2	14.22	− 7,+10,− 2,....	+1.00
381*a*	2.0	17.02	(+ 2,− 1)....,....	16.45	(+ 1,− 1)....,....	+0.57
381*b*	2.0	17.38	(+ 4,− 4)....,....	17.12	(− 8,+ 8)....,....	+0.26
382*	2.0	15.48	− 2,+21,−18,....	15.10	(+22,−22)....,....	+0.38
383	2.3	16.40	+ 2,− 3,....,....	15.58	(−13,+12)....,....	+0.82
385	2.0	15.36	+24,−23,....,....	14.06	(− 4,+ 5)....,....	+1.30
385*a*	2.1	17.46	(− 8,+ 9)....,....	16.94	(− 1,+ 1)....,....	+0.52
385*b*	2.0	17.36	(−11,+10)....,....	16.92	(− 8,+ 7)....,....	+0.44
386	3.4	15.94	+13,+ 5,−19,....	15.40	(−10,+10)....,....	+0.54
386*a*	3.5	17.44	(− 2,+ 2)....,....	16.96	(+ 2,− 1)....,....	+0.48
387	2.1	14.75	+ 4,− 2,....,− 3	13.85	− 3,+ 1,+ 3,....	+0.90
387*a*	2.1	16.86	(+14,−13)....,....	16.06	(− 9,+10)....,....	+0.80
389	1.8	15.46	0,− 3,....,+ 2	14.62	(....,+ 2)− 1,....	+0.84

TABLE II—*Continued*

Number	Distance	Photographic		Photo-visual		Color-Index
		Mag.	Residuals	Mag.	Residuals	
392...	2′9	16.30	− 3,+ 7,....,− 4	15.60	(− 5,+ 4)....,....	+0.70
393...	8.1	15.55	−12,+ 6,+ 7,....	14.63	(....,+ 1)− 1,....	+0.92
394...	1.7	15.94	+ 7,+14,....,−22	15.38	(− 8,+ 7)....,....	+0.56
394*a*..	1.8	16.40	(− 1,+ 1)....,....	15.70	(− 1, 0)....,....	+0.70
396*a*..	2.7	16.83	(−13,+13)....,....	15.97	(−19,+19)....,....	+0.86
397*a*..	1.6	15.49	(+ 1,− 1)....,....	15.61	(...., m)....,....	−0.12
398...	3.0	14.32	−19,− 5,+11,+12	13.19*	− 7,− 4,....,....	+1.13
399...	3.3	16.45	−20,−11,+23,+ 7	15.84	(+ 3,− 3)....,....	+0.61
400...	1.6	15.90	+ 5,+ 9,....,−15	15.34	(−12,+11)....,....	+0.56
401...	2.1	16.16	+ 1,− 1,....,....	15.18	(− 1,+ 2)....,....	+0.98
403...	1.6	15.42	+ 8,− 8,....,....	15.32	(+ 8,− 7)....,....	+0.10
403*a*..	1.7	16.47	(− 8,+ 8)....,....	15.78	(+ 9,− 8)....,....	+0.69
403*b*..	1.7	16.28	(− 6,+ 7)....,....	15.60	(− 5,+ 4)....,....	+0.62
403*c*..	1.5	15.96	(− 8,+ 8)....,....	15.38	(+ 2,− 2)....,....	+0.58
403*d*..	1.7	17.34	(−20,+21)....,....	16.99	(...., m)....,....	+0.35
403*e*..	1.7	17.44	(+ 1,− 2)....,....	17.45	(...., m)....,....	−0.01
403*f*...	1.6	17.41	(+ 4,− 4)....,....	17.24	(...., m)....,....	+0.17
403*g*..	1.6	17.44	(− 9,+ 8)....,....	16.78	(...., m)....,....	+0.66
406...	2.6	16.53	− 6,− 5,+ 5,+ 4	15.71	(+ 7,− 7)....,....	+0.82
411*a*..	4.8	16.96	(+ 1, 0)....,....	16.53	(+12,−12)....,....	+0.43
412...	3.1	15.59	− 5,+14,....,− 8	15.56	(...., m)....,....	+0.03
414...	2.5	16.38	− 4,+ 3,....,....	15.70	(− 1, 0)....,....	+0.68
417...	1.6	14.09	− 2,+ 2,....,....	12.94	+ 8,− 5,− 3,....	+1.15
417*a*..	1.7	15.04	(− 6,+ 7)....,....	15.21	(− 1,+ 1)....,....	−0.17
417*b*..	1.7	16.42	(− 3,+ 2)....,....	16.05	(− 8,+ 8)....,....	+0.37
417*c*..	1.8	17.04	(− 4,+ 5)....,....	16.25	(− 1,+ 1)....,....	+0.79
417*d*..	1.9	17.42	(− 4,+ 4)....,....	16.48	(− 2,+ 3)....,....	−0.06
418...	2.1	15.60	+16,+13,−28,....	15.44	(− 2, +3)....,....	+0.16
418*a**.	2.1	......	....,....,....,....	16.64	(+20,−20)....,....	......
419...	2.6	15.63	−13,+14,....,− 2	15.46	(− 4,+ 4)....,....	+0.17
419*a**.	2.6	17.04	(+ 4,− 3)....,....	16.14	(−14,+15)....,....	+0.90
420*..	1.4	13.59	m,....,....,....	13.40	+ 7,− 6,− 1,....	+0.19
422...	2.4	15.55	+12,+10,−23,....	15.48	(− 8,+ 8)....,....	+0.07
422*a*..	2.3	17.24	(+14,−15)....,....	16.54	(−15,+15)....,....	+0.70
423...	10.6	14.92	− 1,− 7,+ 9,....	14.60	(....,+ 7)− 6,....	+0.32
425*a*..	1.8	16.18	(− 6,+ 5)....,....	15.46	(−16,+15)....,....	+0.72
426...	11.2	14.85	+ 2,− 4,+ 1,....	13.75	....,...., m,....	+1.10
433...	2.9	15.92	− 3,+12,....,−10	15.84	(−12,+12)....,....	+0.08
434...	2.4	16.90	− 5,+ 4,....,....	16.10	(− 1, 0)....,....	+0.80
435...	6.7	15.84	+ 8,− 7,....,....	15.00	(− 2,+ 3)....,....	+0.84
436...	2.1	16.66	0, 0,....,....	15.84	(− 3,+ 3)....,....	+0.82
444...	2.5	15.39	+18,− 1,−16,....	15.42	(+ 3,− 3)....,....	−0.03
450...	2.1	16.86	− 4,+ 5,....,....	16.10	(−10,+10)....,....	+0.76
452...	1.9	15.34	+ 1,−13,....,+11	14.44	(−11,+11)....,....	+0.90
452*a*..	2.1	17.38	(0,− 1)....,....	16.64	(+11,−10)....,....	+0.74
452*b*..	2.2	16.94	(− 8,+ 7)....,....	16.25	(+ 2,− 2)....,....	+0.69
452*c*..	1.9	17.38	(− 7,+ 8)....,....	16.78	(+10,−11)....,....	+0.60
454...	2.5	16.92	−22,+22,....,....	16.20	(− 2,+ 3)....,....	+0.72
455*a*..	5.7	17.52	(0, 0)....,....	16.99	(−15,+15)....,....	+0.53
457...	2.7	16.80	−10,+11,....,....	16.52	(+ 1,− 1)....,....	+0.28
463...	2.4	14.25	−21,+ 2,....,+19	13.12*	− 4,− 3,− 8,....	+1.13
464...	1.9	16.22	− 7,+12,....,− 4	15.40	(−18,+19)....,....	+0.82

TABLE II—*Continued*

Number	Distance	Photographic Mag.	Photographic Residuals	Photo-visual Mag.	Photo-visual Residuals	Color-Index
465...	2′.5	15.01	+ 7,− 4,....,− 3	14.01	+ 5,− 2,− 2,....	+1.00
467...	2.7	15.75	− 8,+20,− 9,− 4	15.67	(− 3,+ 3)....,....	+0.08
467*a*..	2.6	17.36	(+ 2,− 2)....,....	16.66	(− 9,+ 9)....,....	+0.70
467*b*..	2.7	17.28	(− 3,+ 2)....,....	16.76	(+ 8,− 9)....,....	+0.52
471...	3.4	16.14	+23,−24,....,....	15.77	(+ 1,− 1)....,....	+0.37
471*a*..	3.5	16.70	(− 4,+ 3)....,....	15.94	(− 7,+ 6)....,....	+0.76
472...	1.9	14.76	+11,−20,+10,....	14.45	...., m,....,....	+0.31
473...	3.0	16.33	− 1,+ 1,....,....	15.60	(+ 1,− 1)....,....	+0.73
474...	1.7	15.73	−10,+17,....,− 8	15.61	(− 3,+ 3)....,....	+0.12
480...	3.3	16.28	− 3,+ 2,....,....	15.49	(− 7,+ 7)....,....	+0.79
480*a*..	3.7	17.05	(− 8,+ 8)....,....	16.50	(+ 3,− 4)....,....	+0.55
480*b*..	4.0	17.52	(...., m)....,....	17.16	(0,+ 1)....,....	+0.36
482...	2.2	15.92	+ 6,− 6,....,....	15.57	(− 2,+ 2)....,....	+0.35
482*a*..	2.1	16.50	(−13,+12)....,....	15.70	(− 9,+ 9)....,....	+0.80
482*b*..	2.1	16.39	(− 2,+ 2)....,....	15.66	(+ 3,− 2)....,....	+0.73
484...	9.2	16.13	+ 9,− 9,....,....	15.43	(+ 4,− 4)....,....	+0.70
490...	2.0	14.13	+ 5,−14,+10,....	12.33	0,+ 3,− 2,....	+1.80
499...	3.4	16.26	− 1, 0,....,....	15.62	(+ 2,− 3)....,....	+0.64
499*a*..	3.5	17.24	(+11,−11)....,....	16.87	(− 8,+ 8)....,....	+0.37
499*b*..	4.0	17.01	(− 8,+ 8)....,....	16.56	(− 3,+ 2)....,....	+0.45
499*c*..	4.1	17.34	(− 3,+ 3)....,....	16.83	(− 8,+ 8)....,....	+0.51
499*d*..	3.9	17.46	(...., m)....,....	17.31	(...., m)....,....	+0.15
499*e*..	3.9	.....	....,....,....,....	17.48	(...., m)....,....	......
499*f*...	3.9	17.44	(...., m)....,....	17.31	(...., m)....,....	+0.13
499*g*..	4.0	17.19	(−11,+11)....,....	16.88	(− 4,+ 3)....,....	+0.31
499*h*..	4.0	17.59	(...., m)....,....	17.21	(−17,+17)....,....	+0.38
502...	2.4	16.14	+ 3,− 3,....,....	15.21	(− 1,+ 1)....,....	+0.93
502*a*..	2.3	16.20	(0, 0)....,....	15.64	(+ 3,− 3)....,....	+0.56
512...	5.0	15.79	+ 4,+ 7,−11,....	14.94	(+14,−15)....,....	+0.85
513...	2.2	16.03	+ 9,+ 1,....,−11	15.18	(− 6,+ 7)....,....	+0.85
513*a*..	2.3	17.19	(−11,+11)....,....	16.40	(− 7,+ 6)....,....	+0.79
514...	2.9	15.44	+ 2,− 1,....,....	14.58	....,...., m,....	+0.86
522...	3.1	16.54	− 7,+ 6,....,....	15.76	(− 7,+ 8)....,....	+0.78
522*a*..	3.2	16.72	(− 6,+ 5)....,....	16.14	(− 5,+ 6)....,....	+0.58
522*b*..	3.0	16.94	(− 1,+ 2)....,....	16.34	(+ 2,− 2)....,....	+0.60
522*c**.	3.0	.....	....,....,....,....	16.79	(m,....)....,....	......
530...	2.4	16.98	−16,+16,....,....	16.50	(−14,+15)....,....	+0.48
539*..	1.8	15.16	−18,+22,....,− 3	14.98	(m,....)....,....	+0.18
550...	1.8	15.99	+11,+ 9,....,−20	15.10	(− 2,+ 2)....,....	+0.89
550*a*..	1.8	17.36	(−18,+19)....,....	16.86	(+12,−11)....,....	+0.50
564...	1.9	15.94	+16,+ 5,−22,....	14.97	(+ 3,− 6)....,+ 3	+0.97
566...	2.4	16.13	− 1,− 2,....,+ 3	15.17	(0, 0)....,....	+0.96
568...	3.9	16.16	− 6,+ 2,+ 5,....	15.44	(+ 1,− 2)....,....	+0.72
573...	3.4	15.28	− 3,− 7,....,+10	14.62	....,−17,+ 5,.... (....,+11)	+0.66
573*a*..	3.3	17.19	(−11,+11)....,....	16.67	(+21,−21)....,....	+0.52
578...	2.0	16.18	+ 4,− 3,....,....	15.28	(+ 2,− 6)....,+ 4	+0.90
581...	1.6	16.35	− 1,+ 2,− 2,....	15.34	(+ 3,− 4)....,....	+1.01
589...	1.5	13.71	0, 0,....,....	12.80	− 2,+13,−10,....	+0.91
590...	3.5	16.00	−14,+22,....,− 8	15.17	(− 5,+ 5)....,....	+0.83
590*a*..	3.7	17.11	(− 3,+ 2)....,....	16.61	(−11,+11)....,....	+0.50
594...	10.4	15.39	−17,+17,....,....	14.85	(− 3,+ 3)....,....	+0.54
595...	7.9	15.54	−15,+15,....,....	15.40	(− 8,+ 7)....,....	+0.14

TABLE II—*Continued*

Number	Distance	Photographic		Photo-visual		Color-Index
		Mag.	Residuals	Mag.	Residuals	
595*b**	7′.4	17.37:	(...., m)....,....	16.92	−22,+22,....,....	+0.45:
596...	2.0	15.80	+ 6,+10,....,−15	15.12	(0, 0)....,....	+0.68
603...	1.8	15.69	+17,+17,−34,....	15.60	(− 2,+ 1)....,+ 2	+0.09
605...	2.3	15.86	+ 6,+ 9,−14,....	15.31	(+11,−11)....,....	+0.55
605*a*..	2.3	17.10	(− 6,+ 7)....,....	16.48	(+ 2,− 2)....,....	+0.62
606...	1.9	15.64	+22,+ 9,− 32,...	15.47	(0,− 5)....,+ 6	+0.17
609†..	4.1	15.66	− 4,+ 7,....,− 2	15.70	(− 3,+ 3)....,....	−0.04
609*a*..	4.0	17.42	(−11,+10)....,....	16.94	(− 1,+ 1)....,....	+0.48
609*b*..	4.3	17.53	(− 5,+ 2)....,....	17.31	(+ 9,− 4)....,....	+0.21
612‡..	1.3	13.96	....,....,− 2,+ 2	12.58	....,− 9,....,....	+1.38
621...	3.1	15.07	+ 1,+ 2,....,− 2	13.97	+ 3,+ 1,− 4,....	+1.10
621*a*..	3.2	16.92	(− 2,+ 1)....,....	16.26	(− 2,+ 3)....,....	+0.66
621*b*..	3.2	17.15	(−11,+11)....,....	16.80	(− 5,+ 4)....,....	+0.35
621*d*..	3.2	17.79:	(− 4,+ 4)....,....	17.38	(...., m)....,....	+0.41:
628...	1.6	16.37	− 3, 0,+ 4,....	15.52	(+ 6,− 7)....,....	+0.85
628*a*..	1.6	16.34	(+ 3,− 2)....,....	15.38	(+15,−16)....,....	+0.96
632...	5.1	15.62	+ 5,+20,−25,....	15.38	(+ 9,−10)....,....	+0.24
639...	2.1	16.06	− 2,+ 9,....,− 8	15.18	(− 6,+ 7)....,....	+0.88
640†..	2.7	14.40	− 1,+16,−11,− 3	13.22	−10,+ 1,+ 9,....	+1.18
640*a*..	3.0	17.15	(+ 6,− 6)....,....	16.85	(− 6,+ 6)....,....	+0.30
640*b*..	3.2	17.05	(+16,−16)....,....	16.48	(+ 2,− 2)....,....	+0.57
640*c*..	3.0	17.50	(−15,+15)....,....	16.98	(− 5,+ 5)....,....	+0.52
640*d*..	3.1	17.32	(− 1,+ 2)....,....	16.98	(−23,+22)....,....	+0.34
640*e*..	3.2	17.30	(−12,+12)....,....	17.04	(−16,+16)....,....	+0.26
640*f*...	2.8	17.42	(− 7,+ 7)....,....	17.17	(...., m)....,....	+0.25
649...	4.1	15.98	+14,− 3,− 10,....	15.35	(+ 2,− 2)....,....	+0.63
649*a*..	4.3	17.02	(+ 2,− 1)....,....	16.71	(− 1,+ 1)....,....	+0.31
649*b*..	4.3	17.16	(− 2,+ 1)....,....	16.82	(− 3,+ 2)....,....	+0.34
649*c*..	3.8	17.17	(− 9,+ 9)....,....	16.74	(+10,− 9)....,....	+0.43
659...	4.0	15.52	− 6,+ 4,....,+ 2	15.49	(− 7,+ 7)....,....	+0.03
665...	2.0	15.88	+10,+16,−26,....	15.84	(+ 6,− 5)....,....	+0.04
665*a*..	2.1	17.28	(− 3,+ 2)....,....	16.90	(+14,−15)....,....	+0.38
667*..	1.5	16.14	− 4,....,+ 3,....	.....	....,....,....,....	......
674...	1.8	16.24	+21,−20,....,....	15.53	(m,....)....,....	+0.71
675...	2.5	15.79	+ 4,+ 7,....,−11	16.03	(−13,+13)....,....	−0.24
680...	1.6	14.75	+ 4,− 2,....,− 3	13.66	− 2,−13,+16,....	+1.09
680*a*..	1.6	15.80	−11,+12,....,....	15.58	(+ 6,− 5)....,....	+0.22
680*b*..	1.6	15.78	(0,− 1)....,....	15.58	(− 5,+ 6)....,....	+0.20
680*c*..	1.7	16.37	(+ 2,− 2)....,....	15.60	(− 5,+ 4)....,....	+0.77
700*a*..	2.4	16.40	(− 3,+ 4)....,....	15.76	(+ 8,− 9)....,....	+0.64
701...	5.0	16.45	+14,−15,....,+ 1	15.68	(− 7,+ 8)....,....	+0.77
701*a*..	6.0	16.72	(− 2,+ 1)....,....	16.08	(− 5,+ 5)....,....	+0.64
701*b*..	5.2	17.33	(− 2,+ 2)....,....	16.88	(− 4,+ 3)....,....	+0.45
701*c*..	5.0	17.35	(− 7,+ 7)....,....	17.06	(−18,+18)....,....	+0.29
701*d*..	5.0	17.36	(−11,+10)....,....	16.94	(−15,+16)....,....	+0.42
706...	1.5	14.06	−14,+ 5,....,+10	12.90	+14,− 1,−12,....	+1.16
707...	1.8	16.73	+12,− 1,....,−11	15.84	(− 3,+ 3)....,....	+0.89
708...	1.9	15.30	+16,−17,....,− 1	15.43	(−16,+16)....,....	−0.13
709...	11.4	14.26	−16,+16,....,....	14.13	(+ 7,− 7)....,....	+0.13
713*a*..	9.0	.....	....,....,....,....	16.64	(−14,+14)....,....	......
724...	2.1	16.74	− 2,+ 3,....,....	16.03	(−10,+10)....,....	+0.71
730...	1.6	16.14	....,+ 1,− 1,....	15.15	(+ 2,−15)....,+13	+0.99

TABLE II—*Continued*

Number	Distance	Photographic Mag.	Photographic Residuals	Photo-visual Mag.	Photo-visual Residuals	Color-Index
730*a*..	1ʹ.6	17.70	(−14,+13)....,....	16.94	(−10,+ 9)....,....	+0.76
738...	1.6	16.70	−11,+10,....,....	16.76	(+12,−13)....,....	−0.06
739...	4.9	15.55	−12,+14ʹ....,− 1	15.50	(− 5,+ 6)....,....	+0.05
739*a*..	4.7	16.64	(− 2,+ 2)....,....	16.12	(+ 6,− 6)....,....	+0.52
739*b*..	5.2	16.81	(0, 0)....,....	16.32	(+11,−12)....,....	+0.49
740†..	3.5	14.10	− 8,+ 4,+ 2,+ 1	13.40	−13,+ 6,+ 6,....	+0.70
740*a*..	3.3	17.24	(−14,+14)....,....	17.25	(−27,+13)....,....	−0.01
740*b*..	3.3	17.40	(− 2,+ 2)....,....	17.14	(−16,+17)....,....	+0.26
752...	1.2	13.96	....,....,− 6,+ 7	12.54	....,− 7,....,....	+1.42
753...	1.5	15.09	−11,+ 4,....,+ 8	13.95	− 2,+ 1,+ 2,....	+1.14
758...	1.6	16.07	+ 3,+ 8,−12,....	15.04	(+ 8,−16)....,+ 9	+1.03
758*a*..	1.7	17.58	(−10,+11)....,....	17.10	(−22,+21)....,....	+0.48
759*a**.	2.2	.....	....,....,....,....	16.51	(− 5,+ 5)....,....	......
767...	2.0	15.89	−10,+19,....,−10	15.42	(−12,+11)....,....	+0.47
777...	2.4	16.94	− 1, 0,....,....	16.42	(+ 4,− 4)....,....	+0.52
801...	1.3	15.59	+ 1,+23,−24,....	15.47	(+11,−11)....,....	+0.12
801*a*..	1.4	17.06	(− 2,+ 3)....,....	16.25	(− 1,+ 1)....,....	+0.81
801*b*..	1.4	17.47	(+ 1,− 1)....,....	17.14	(−10,+10)....,....	+0.33
801*c*..	1.5	......	....,....,....,....	17.24	(...., m)....,....	......
805...	1.6	15.57	− 3,− 1,....,+ 4	15.57	(− 4,+ 4)....,....	0
810...	2.2	16.06	+ 1,− 2,....,....	15.98	(− 8,+ 8)....,....	+0.08
811...	1.6	15.88	+19,−15,....,− 3	15.14	(+ 8,− 8)....,....	+0.74
832...	2.8	15.23	− 8,+ 2,....,+ 5	14.47	....,− 5,....,....	+0.76
					(....,+ 5)	
837...	3.9	13.83	− 8,−17,+20,+ 4	12.47	+ 4,+ 9,−12,....	+1.36
837*b*..	4.0	17.13	(−13,+13)....,....	16.75	(0, 0)....,....	+0.38
841...	5.6	15.59	−16,+ 6,+13,− 1	15.36	(+ 6,− 6)....,....	+0.23
845...	1.8	15.62	+14,+28,−41,....	15.58	(+ 6,+ 3)....,− 8	+0.04
845*a*..	1.8	17.26	(−16,+16)....,....	16.52	(+13,−14)....,....	+0.74
853...	4.0	14.56	−19,+21,− 2,....	13.63	− 8, 0,+ 7,....	+0.93
872...	3.4	15.18	− 7,− 5,− 3,+13	14.40	−17,− 8, 0,....	+0.78
					(....,+27)	
879...	1.5	15.58	− 8,+ 7,...., 0	15.10	(+20,....)−19,....	+0.48
882...	1.7	15.99	+16, 0,−16,....	15.14	(+ 3,....)....,− 3	+0.85
883...	3.7	16.00	− 2,− 1,+17,−15	15.40	(+ 7,− 7)....,....	+0.60
885...	1.9	14.47	− 6,+ 9,− 4,....	13.27	− 6,+ 2,+ 4,....	+1.20
885*a*..	2.0	17.22	(− 8,+ 8)....,....	16.54	(+ 3,− 3)....,....	+0.68
900...	2.1	16.24	+ 1,− 2,....,....	15.28	(− 3,+ 2)....,....	+0.96
900*a*..	2.4	16.98	(+ 6,− 5)....,....	16.44	(+ 9,− 9)....,....	+0.54
900*b*..	2.5	17.41	(+ 4,− 4)....,....	17.20	(...., m)....,....	+0.21
902...	2.4	15.85	+ 4,+10,....,−13	15.26	(− 1,+ 2)....,....	+0.59
902*a*..	2.4	17.34	(− 3,+ 3)....,....	16.68	(+ 7,− 8)....,....	+0.66
902*b*..	2.3	17.50	(−12,+13)....,....	17.02	(− 4,+ 5)....,....	+0.48
925...	2.8	14.29	−11,− 2,+14,....	12.95	−11,− 2,+12,....	+1.34
925*a*..	2.8	16.28	(+ 2,− 2)....,....	15.54	(− 4,+ 5)....,....	+0.74
925*b*..	2.9	17.66	(−18,+17)....,....	17.24	(− 2,+ 3)....,....	+0.42
925*c*..	3.0	17.46	(− 8,+ 9)....,....	16.92	(−15,+15)....,....	+0.54
925*d**.	2.9	17.31	(− 3,+ 3)....,....	16.96	(−21,+21)....,....	+0.35
925*e*..	2.9	17.38	(− 7,+ 8)....,....	17.11	(−18,+ 9)....,....	+0.27
926*..	4.2	14.65	m,....,....,....	14.43	....,− 5,+ 5,....	+0.22
926*a*..	4.2	17.10	(− 6,+ 7)....,....	16.74	(+14,−28)....,....	+0.36
935...	10.0	15.77	+27,−12,−15,....	14.70	(....,+12)−11,....	+1.07

TABLE II—*Continued*

Number	Distance	Photographic Mag.	Photographic Residuals	Photo-visual Mag.	Photo-visual Residuals	Color-Index
945..	1′.6	16.36	− 2,+ 1,....,....	15.50	(+ 8,− 8)...., 0	+0.86
945*a*.	1.6	16.12	(0,− 1)....,....	15.21	(+ 1,− 1)....,....	+0.91
945*b*.	1.7	16.60	(+ 2,− 2)....,....	15.58	(0,+ 1)....,....	+1.02
952..	1.7	16.16	− 4,+ 6,....,− 3	16.19	(− 7,+ 7)....,....	−0.03
953..	1.5	15.84	−11,+11,....,....	15.22:	(....,+ 8)−17,....	+0.62:
955..	10.1	14.92	+12,− 7,− 4,....	14.55	(...., 0) 0,....	+0.37
962..	10.0	15.79	+31,−14,−17,....	14.86	(....,+ 8)− 8,....	+0.93
969..	8.5	16.15	0, 0,....,....	15.76	(− 7,+ 8)....,....	+0.39
974..	7.7	16.10	0,+ 1,....,....	14.97	(+ 6,− 6)....,....	+1.13
974*a*.	7.0	16.78	(+ 1,− 1)....,....	16.26	(−11,+ 6)....,....	+0.52
982‡.	1.3	15.98	....,....,− 9,+ 9	15.32	....,....,....,....	+0.66
1000..	3.0	14.08	−20,− 9,+15,+12	12.83	+13,− 7,− 5,....	+1.25
1000*a*.	2.8	17.45	(−14,+14)....,....	16.88	(0, 0)....,....	+0.55
1009..	4.0	15.67	− 4,+19,−16,....	15.76	(+ 2,− 3)....,....	−0.09
1012..	1.7	15.72	− 2,+ 1,...., 0	15.64	(0, 0)....,....	+0.08
1014..	1.9	15.69	+ 4,+13,−18,....	14.96	(+12,−11)....,....	+0.73
1017..	6.6	16.39	+ 9,+ 2,....,−12	15.96	(−15,+14)....,....	+0.43
1022..	2.0	16.66	−16,+16,....,....	16.44	(+ 2,− 3)....,....	+0.22
1022*a*.	2.1	16.82	(− 3,+ 3)....,....	16.97	(−13,+13)....,....	−0.15
1028..	2.3	15.66	−12,+11,....,....	14.73	....,− 6,+ 8,.... (....,− 3)	+0.93
1028*a*.	2.3	17.27	(+18,−18)....,....	16.92	(+12,−11)....,....	+0.35
1028*b*.	2.2	16.54	(−17,+16)....,....	15.96	(− 6,+ 7)....,....	+0.58
1028*c*.	2.2	17.46	(...., m)....,....	17.07	(...., m)....,....	+0.39
1039..	2.0	15.02	+ 2,− 9,....,+ 7	13.96	−11,+ 5,+ 5,....	+1.06
1047..	1.8	15.95	0,+ 4,....,− 3	14.99	(− 1,+ 1)....,....	+0.96
1050..	1.6	15.38	+16,−17,....,....	14.17	....,...., m,....	+1.21
1055†.	4.6	15.95	− 7,+ 7,....,+ 1	15.26	(+14,−14)....,....	+0.69
1061..	2.1	16.64	−14,+13,....,....	15.88	(− 1,+ 2)....,....	+0.76
1062..	1.8	15.35	+19,− 6,−14,....	14.60	(....,− 5)+ 5,....	+0.75
1063..	2.2	16.08	− 7,+ 3,....,+ 5	15.14	(+ 3,− 2)....,....	+0.94
1064..	1.8	16.23	−13,+14,....,− 2	15.25	(− 5,+ 5)....,....	+0.98
1070..	2.1	16.19	− 7,+ 3,....,+ 4	16.20	(− 5,+ 6)....,....	−0.01
1076..	1.8	16.12	− 2,+ 3,....,....	15.56	(− 9,+ 8)....,....	+0.56
1076*a*.	1.9	17.08	(− 8,+ 9)....,....	16.16	(−10,+10)....,....	+0.92
1086..	2.0	16.42	− 8,+ 9,....,....	15.66	(− 2,+ 1)....,....	+0.76
1089..	2.2	15.18	+ 7,+ 3,−11,....	14.09	....,...., m,....	+1.09
1090*a*.	2.1	17.08	(− 8,+ 9)....,....	16.48	(+13,−13)....,....	+0.60
1090*b*.	2.3	17.08	(0,+ 1)....,....	16.47	(+ 6,− 6)....,....	+0.61
1090*c*.	2.3	16.34	(− 4,+ 4)....,....	15.60	(− 5,+ 4)....,....	+0.74
1098..	1.8	16.48	+ 4,− 3,....,....	15.64	(...., m)....,....	+0.84
1101..	4.4	15.90	− 1, 0,....,....	14.88	(+15,−15)....,....	+1.02
1120..	2.2	16.12	+ 5,− 4,....,....	15.96	(− 6,+ 7)....,....	+0.16
1120*a*.	2.3	17.02	(− 2,+ 3)....,....	16.58	(−12,+11)....,....	+0.44
1123..	2.5	15.52	− 2,+21,−20,....	15.52	(+ 9,−10)....,....	0
1123*a*.	2.5	17.32	(− 1,+ 2)....,....	17.03	(...., m)....,....	+0.29
1123*b*.	2.5	17.24	(+11,−11)....,....	16.76	(+ 8,− 7)....,....	+0.48
1123*c*.	2.4	17.56	(m,....)....,....	17.02	(− 4,+ 5)....,....	+0.54
1127..	1.6	13.92	− 9,+ 7,....,+ 3	12.62	....,− 1, 0,....	+1.30
1127*a*.	1.7	16.52	(−13,+14)....,....	15.80	(− 5,+ 4)....,....	+0.72
1128..	3.6	14.08	−20,− 5,+15,+12	14.68	....,−17,+ 1,− 1 (....,+17)	−0.60

TABLE II—*Continued*

Number	Distance	Photographic		Photo-visual		Color-Index
		Mag.	Residuals	Mag.	Residuals	
1128*a*.	3′.5	17.08	(− 4,+ 5)....,....	16.51	(+ 2,− 2)....,....	+0.57
1128*b*.	3.4	17.32	(+ 3,− 2)....,....	16.82	(+ 6,− 7)....,....	+0.50
1128*c*.	3.8	.....	....,....,....,....	17.12	(+10,− 5)....,....	.....
1130..	3.2	15.53	− 3,+12,....,− 8	15.44	(−12,+12)....,....	+0.09
1131†.	4.0	15.81	− 3,+ 7,− 9,+ 5	15.48	(− 6,+ 5)....,....	+0.33
1131*a*.	4.0	17.30	(+ 1, 0)....,....	16.80	(−15,+15)....,....	+0.50
1131*b*.	3.9	17.31	(− 6,+ 6)....,....	16.72	(+ 3,− 3)....,....	+0.59
1137..	2.2	17.05	m,....,....,....	16.62	(−23,+22)....,....	+0.43
1140..	4.4	15.89	+12,− 7,....,− 4	15.06	(+ 2,− 3)....,....	+0.83
1140*a*.	4.5	16.96	(−20,+21)....,....	16.54	(+11,−10)....,....	+0.42
1140*b*.	4.3	17.34	(+ 4,− 4)....,....	17.02	(−14,+15)....,....	+0.32
1140*c*.	4.5	17.38	(− 3,+ 4)....,....	17.10	(...., m)....,....	+0.28
1140*d*.	4.5	17.29	(− 8,+ 8)....,....	16.84	(...., m)....,....	+0.45
1141..	3.0	16.21	− 4,− 3,+ 8,....	15.31	(+19,− 3)....,−15	+0.90
1143..	2.2	15.71	−11,+15,....,− 3	15.02	(+ 6,− 5)....,....	+0.69
1146..	2.9	15.64	+25,+ 9,−34,....	15.58	(0,+ 3)....,− 2	+0.06
1147..	4.6	16.10	+ 5,+ 1,....,− 5	15.53	(− 3,+ 3)....,....	+0.57
1148..	2.6	15.86	+ 3,+ 9,....,−11	15.28	(− 1, 0)....,....	+0.58
1149..	2.0	16.50	−16,+13,....,+ 4	15.70	(+ 5,− 6)....,....	+0.80
1149*a*.	2.0	17.58	(−16,+16)....,....	17.14	(...., m)....,....	+0.44
1149*b*.	1.9	17.54	(−11,+ 5)....,....	16.56	(+ 1,− 2)....,....	+0.98
1149*c*.	2.1	17.37	(−12,+12)....,....	16.87	(+ 6,− 6)....,....	+0.50
1149*d*.	2.1	17.38	(+ 4,− 4)....,....	16.84	(+ 9,− 9)....,....	+0.54
1149*e*.	2.2	17.46	(− 1, 0)....,....	16.96	(− 8,+ 7)....,....	+0.50
1149*f**	2.3	.....	....,....,....,....	17.24	(...., m)....,....	.....
1149*g**	2.3	.....	....,....,....,....	17.20	(...., m)....,....	.....
1154..	2.5	15.89	+15,+ 6,....,−21	15.38	(−11,+12)....,....	+0.51
1154*a*.	2.5	17.21	+ 4,− 4,....,....	16.44	(+ 9,− 9)....,....	+0.77
1158..	6.2	16.80	...., m,....,....	16.56	(− 3,+ 2)....,....	+0.24
1162..	7.7	16.08	− 4,+ 3,....,+ 2	15.30	(+ 2,− 2)....,....	+0.78
1168*.	2.0	16.12	+ 3,+18,−21,....	14.87	....,− 9,+ 6,.... (....,+ 4)	+1.25
1170*.	2.0	15.57	+19,+12,−32,....	14.54	....,+ 5,− 6,....	+1.03
1172..	2.8	15.49	− 6,+ 2,....,+ 5	14.62	(....,− 1)+ 2,....	+0.87
1172*a*.	2.9	16.31	(− 1,+ 1)....,....	15.56	(− 3,+ 3)....,....	+0.75
1172*b*.	3.0	17.28	(− 7,+ 6)....,....	16.68	(+ 2,− 1)....,....	+0.60
1172*c*.	2.8	17.08	(0,+ 1)....,....	16.41	(− 5,+ 5)....,....	+0.67
1173..	2.4	15.35	0,+16,−17,....	14.69	....,...., m,....	+0.66
1174..	1.8	16.56	− 6,+ 7,....,....	15.66	(− 2,+ 1)....,....	+0.90
1175..	2.7	15.37	+ 9,+ 1,−10,....	14.34	(....,− 8)+ 9,....	+1.03
1175*a*.	2.7	17.00	(0,+ 1)....,....	.....	....,....,....,....	.....
1178..	5.3	16.22	+ 3,− 4,....,....	15.60	(+ 7,− 7)....,....	+0.62
1178*a*.	5.0	17.09	(−12,+12)....,....	16.87	(− 8,+ 8)....,....	+0.22
1178*b*.	4.8	17.01	(− 4,+ 4)....,....	16.62	(+ 3,− 2)....,....	+0.39
1178*c*.	5.4	16.96	(+ 4,− 3)....,....	16.62	(−19,+19)....,....	+0.34
1178*d*.	5.4	17.21	(+ 4,− 4)....,....	17.20	(...., m)....,....	+0.01
1181*a*.	3.0	17.32	(−11,+10)....,....	16.66	(−16,+15)....,....	+0.66
1181*b*.	3.1	17.10	(− 2,+ 3)....,....	16.48	(+ 2,− 2)....,....	+0.62
1182..	2.2	16.18	+ 2,− 3,....,....	15.14	(+ 3,− 2)....,....	+1.04
1186..	2.4	16.01	− 3,+10,....,− 6	15.32	(+ 8,− 7)....,....	+0.69
1192..	2.0	16.22	− 5,+ 4,....,+ 1	15.39	(...., m)....,....	+0.83
1199..	2.8	15.55	− 1,− 4,....,+ 6	14.76	(....,+ 6)− 6,....	+0.79

TABLE II—*Continued*

Number	Distance	Photographic		Photo-visual		Color-Index
		Mag.	Residuals	Mag.	Residuals	
1201*a*.	3′6	17.49:	(...., m)....,....	16.98	(0,+ 1)....,....	+0.51:
1201*b*.	3.6	17.48	(− 3,+ 1)....,....	17.05	(−26,+26)....,....	+0.43
1201*c**	3.5	17.04:	(m,....)....,....	17.31:	(...., m)....,....	−0.27:
1201*d**	3.5	17.35:	(m,....)....,....	17.10	(−22,+21)....,....	+0.25:
1203..	2.7	14.40	−14,− 1,....,+14	13.08	+ 4,− 3,− 2,....	+1.32
1204..	2.6	16.02	....,....,− m,....	15.22	(− 2,+ 3)....,....	+0.80
1205..	2.2	16.86	− 9,+ 8,....,....	16.68	(+ 7,− 8)....,....	+0.18
1205*a*.	2.3	.....	....,....,....,....	17.00	(− 2,+ 3)....,....	......
1206..	1.8	16.15	−11,+11,....,....	15.20	(− 3,+ 2)....,....	+0.95
1206*a*.	1.8	17.00	(0,+ 1)....,....	16.08	(−11,+12)....,....	+0.92
1206*b*.	1.7	16.32	(− 2,+ 3)....,....	15.40	(+ 5,− 4)....,....	+0.92
1206*c*.	1.8	16.04	(− 6,+ 7)....,....	15.36	(+ 1, 0)....,....	+0.68
1208..	2.0	14.40	−14,+ 3,....,+11	13.17	0,+ 2,− 2,....	+1.23
1210..	6.4	16.00	+ 4,− 5,....,....	15.57	(+ 4,− 4)....,....	+0.43
1211..	1.9	15.82	+13,−14,+ 9,−10	15.12	(+10,− 9)....,....	+0.70
1212..	2.0	15.34	+16,− 5,−11,....	14.57	....,+ 2,+13,.... (....,−15)	+0.77
1213..	2.0	15.36	+10,+ 2,−13,....	15.12	(+13,−12)....,....	+0.24
1214..	1.8	14.40	−27,+12,+14,....	13.18	+ 9,−13,+ 4,....	+1.22
1215..	1.9	16.02	+ 2,− 3,....,....	15.75	(m,....)....,....	+0.27
1216..	1.9	16.61	−14,+14,....,....	15.86	(− 2,+ 1)....,....	+0.75
1217..	1.8	14.86	+12,−17,+ 1,+ 5	13.69	...., m,....,....	+1.17
1218..	2.5	16.70	−11,+10,....,....	15.98	(− 5,+ 5)....,....	+0.72
1218*a*.	2.5	17.30	(− 5,+ 4)....,....	16.65	(− 4,+ 4)....,....	+0.65
1218*b*.	2.4	17.31	(− 6,+ 6)....,....	16.84	(+ 9,− 9)....,....	+0.47
1219..	1.9	14.04	− 3,−12,+16,....	12.64	+11,−13,+ 2,....	+1.40
1222*a*.	2.0	17.40	(− 9,+ 9)....,....	16.65	(+14,−14)....,....	+0.75
1222*b*.	2.1	17.22	(−12,+12)....,....	16.44	(+ 2,− 3)....,....	+0.78
1222*c*.	2.2	17.36	(+ 9,−10)....,....	17.03	(...., m)....,....	+0.33
1223..	5.3	16.61	+ 9,− 1,....,− 7	15.82	(− 4,+ 5)....,....	+0.79
1223*a*.	5.1	17.10	(−10,+11)....,....	16.90	(− 2,+ 1)....,....	+0.20
1223*b*.	5.4	17.28	(+ 7,− 7)....,....	16.92	(−27,+28)....,....	+0.36
1224..	2.9	14.78	+ 5,− 9,....,+ 5	13.57	+ 4,− 5,+ 1,....	+1.21
1225..	1.9	15.33	+ 6,− 4,− 3,....	14.46	....,− 8,+11,.... (....,− 4)	+0.87
1225*a*.	2.0	17.04	(− 4,+ 3)....,....	16.44	(+ 6,− 6)....,....	+0.60
1225*b*.	2.0	17.01	(− 8,+ 8)....,....	16.36	(+10,−10)....,....	+0.65
1225*c*.	1.9	17.18	(− 8,+ 7)....,....	16.50	(m,....)....,....	+0.68
1226..	2.1	16.02	− 1,+ 2,....,....	15.47	(+11,−11)....,....	+0.55
1227*.	4.0	16.36	+ 6,− 6,....,....	15.57	(− 2,+ 2)....,....	+0.79
1227*a*.	4.1	16.98	(+ 6,− 5)....,....	16.31	(−10,+10)....,....	+0.67
1227*b*.	4.1	17.28	(− 3,+ 2)....,....	17.00	(+ 4,− 5)....,....	+0.28
1227*c*.	4.0	17.40	(− 5,+ 6)....,....	16.94	(− 1,+ 1)....,....	+0.46
1227*d*.	3.8	17.34	(− 9,+ 8)....,....	17.12	(− 2,+ 2)....,....	+0.22
1229..	2.1	15.63	− 9,+ 9,....,....	14.64	(....,+ 3)− 3,....	+0.99
1230..	2.3	16.71	+ 6,−11,....,+ 6	16.03	(−13,+13)....,....	+0.68
1235..	2.2	16.31	− 4,+ 4,....,....	15.24	(− 4,+ 4)....,....	+1.07
1236..	2.0	15.35	+15,− 6,− 8,....	14.32	(....,+ 1) 0,....	+1.03
1236*a*.	1.9	16.52	(+10,−11)....,....	15.71	(+ 1,− 1)....,....	+0.81
1238..	2.1	15.78	− 8,+ 8,....,....	15.64	(0, 0)....,....	+0.14
1239..	2.2	15.24	+ 1,+ 5,− 6,....	14.56	....,....,− 6,+ 7	+0.68
1240..	3.0	15.84	−11,+11,....,....	15.22	(− 5,+ 6)....,....	+0.62

TABLE II—*Continued*

Number	Distance	Photographic Mag.	Photographic Residuals	Photo-visual Mag.	Photo-visual Residuals	Color-Index
1241*.	2′.1	15.00	+ 8,+21,−29,....	13.70	....,− 4,+ 5,....	+1.30
1242..	2.1	15.98	+ 3,+ 5,− 7,....	15.77	(+ 7,− 7)....,....	+0.21
1242*a*.	2.3	16.55	(+11,−11)....,....	15.68	(+ 4,− 4)....,....	+0.87
1243..	2.8	16.37	−10,− 7,+15,+ 1	15.60	(− 5,+ 4)....,....	+0.77
1243*a*.	2.8	16.67	(+ 5,− 5)....,....	16.24	(0,− 1)....,....	+0.43
1244*.	2.1	15.79	− 3,+25,−21,....	14.59	....,−32,+ 2,.... (....,+14)	+1.20
1244*a*.	2.1	17.16	(− 2,+ 1)....,....	16.42	(− 3,+ 4)....,....	+0.74
1246..	2.5	15.01	0, 0,....,....	14.01	+ 4,− 3,− 2,....	+1.00
1247..	2.2	15.81	−14,+14,....,....	15.70	(− 1, 0)....,....	+0.11
1247*a*.	2.4	16.94	(+ 6,− 5)....,....	16.34	(− 7,+ 7)....,....	+0.60
1247*b*.	2.3	17.04	(0,+ 1)....,....	16.40	(− 7,+ 6)....,....	+0.64
1249..	2.4	16.18	+ 4,− 3,....,....	16.13	(−10,+10)....,....	+0.05
1250*a*.	5.6	16.94	(− 8,+ 7)....,....	16.28	(−10,+10)....,....	+0.66
1251..	7.1	16.50	0,+ 1,....,....	15.74	(− 2,+ 2)....,....	+0.76
1254..	7.4	15.82	+ 1, 0,....,....	15.57	(+ 4,− 4)....,....	+0.25
1254*a*.	7.5	16.01	(− 7,+ 7)....,....	15.62	(− 1,+ 2)....,....	+0.39
1255..	2.4	15.61	+ 6,−14,....,+ 7	15.48	(− 3,+ 2)....,....	+0.13
1258..	2.1	15.21	+ 4,+ 8,−12,....	14.26	(....,− 1)+ 1,....	+0.95
1260..	2.2	15.80	+ 6,− 7, 0,....	15.24	(− 2,+ 1)....,....	+0.56
1261..	3.2	15.30	+13,−13,− 7,+ 8	14.58	(....,+ 2)− 3,....	+0.72
1261*a*.	3.4	15.98	(− 7,+ 6)....,....	15.52	(+ 1,− 2)....,....	+0.46
1262..	2.2	15.43	− 8,+22,−13,....	15.30	(+ 2,− 2)....,....	+0.13
1263..	7.3	15.35	+ 4,−10,+ 6,....	15.38	(− 8,+ 9)....,....	−0.03
1264..	8.2	15.98	+ 8,− 8,....,....	15.36	(− 4,+ 3)....,....	+0.62
1265*a*.	3.4	16.84	(−12,+12)....,....	16.37	(− 1,+ 1)....,....	+0.47
1265*b*.	3.4	16.45	(− 8,+ 8)....,....	15.82	(+ 2,− 3)....,....	+0.63
1265*c*.	3.4	17.28	(− 7,+ 6)....,....	16.88	(− 4,+ 3)....,....	+0.40
1265*d*.	3.5	17.42	(− 7,+ 7)....,....	16.94	(− 6,+ 5)....,....	+0.48
1265*e*.	3.7	16.76	(− 6,+ 5)....,....	16.24	(+ 3,− 4)....,....	+0.52
1265*f*.	3.6	17.30	(+ 5,− 4)....,....	17.12	(−19,+19)....,....	+0.18
1265*g*.	3.5	15.96	(− 2,+ 1)....,....	15.08	(−10,+ 9)....,....	+0.88
1269..	6.0	14.73	+ 8,+ 8,−14,− 1	13.86	− 9,.... + 9,....	+0.87
1270..	6.5	14.85	−24,+20,....,+ 5	13.86	+ 1,− 5,+ 5,....	+0.99
1270*a*.	6.4	17.21	(−13,+13)....,....	16.84	(− 5,+ 4)....,....	+0.37
1270*b*.	6.4	17.02	(+ 6,− 6)....,....	16.84	(− 5,+ 4)....,....	+0.18
1271..	2.7	15.69	+20, 0,−18,− 1	14.68	....,+10,....,.... (....,− 9)	+1.01
1271*a*.	2.8	16.64	(+ 2,− 2)....,....	15.96	(− 6,+ 7)....,....	+0.68
1273..	2.8	14.53	−20,+ 3,+ 1,+15	13.29	+ 3, 0,− 4,....	+1.24
1274..	2.6	15.24	+ 1,− 7,− 6,+14	14.57	....,− 2,− 3,.... (....,+ 4)	+0.67
1275..	5.1	16.22	− 2,− 7,+ 7,+ 1	15.37	(−10,+10)....,....	+0.85
1278..	2.4	16.24	− 7,+ 6,....,....	15.29	(−14,+ 4)....,+11	+0.95
1278*a*.	2.3	17.61	(+17,− 9)....,....	17.24	(...., m)....,....	+0.37
1279..	2.4	15.94	− 5,....,+ 4,....	15.09	(−11,+11)....,....	+0.85
1280..	3.1	16.75	+ 5,+ 2,....,− 7	16.34	(+ 2,− 2)....,....	+0.41
1280*a*.	3.0	17.36	(− 5,+ 6)....,....	16.84	(−14,+15)....,....	+0.52
1280*b*.	2.9	17.36	(− 1,+ 1)....,....	17.21	(+ 1,− 1)....,....	+0.15
1283..	2.6	16.04	− 6,+ 7,− 2,....	15.03	(+12,−12)....,....	+1.01
1283*a*.	2.7	16.67	(+ 5,− 5)....,....	16.08	(−15,+15)....,....	+0.59
1285..	2.8	15.97	− 8,+ 7,+ 1,+ 1	15.96	(+ 1, 0)....,....	+0.01

TABLE II—*Continued*

Number	Distance	Photographic Mag.	Photographic Residuals	Photo-visual Mag.	Photo-visual Residuals	Color-Index
1285*a*.	3′.1	17.35	(− 7,+ 7)....,....	17.23	(+ 6,− 6)....,....	+0.12
1285*b*.	3.2	17.34	(− 3,+ 3)....,....	17.08	(−10,+ 9)....,....	+0.26
1286..	2.5	16.30	− 3,+ 4,....,....	15.57	(− 7,+ 4)....,+ 2	+0.73
1287..	4.4	15.89	+ 6,+ 1,− 6,....	15.50	(+ 3,+ 6)....,−10	+0.39
1287*a*.	4.4	17.13	(+ 8,− 8)....,....	16.82	(− 3,+ 2)....,....	+0.31
1289..	3.2	16.24	−14,+ 6,....,+ 8	15.38	(−11,+12)....,....	+0.86
1289*a*.	3.1	16.34	(0,+ 1)....,....	15.94	(− 7,+ 6)....,....	+0.40
1290..	2.8	15.46	+17,+ 1,−19,....	14.62	(0,− 1)....,....	+0.84
1290*a*.	3.0	17.34	(− 9,+ 8)....,....	16.90	(− 2,+ 1)....,....	+0.44
1290*b*.	3.0	17.48	(0,+ 1)....,....	16.84	(− 5,+ 4)....,....	+0.64
1292*a*.	2.5	17.36	(+ 2,− 2)....,....	16.86	(+18,−17)....,....	+0.50
1292*b*.	2.5	17.49	(+ 3,− 3)....,....	17.22	(− 6,+ 5)....,....	+0.27
1293..	3.8	16.24	+10,− 9,....,....	15.54	(− 1,+ 2)....,....	+0.70
1293*b*.	3.9	17.34	(− 3,+ 3)....,....	16.94	(−10,+ 9)....,....	+0.40
1293*c*.	3.9	16.27	(+10,−10)....,....	15.58	(0,+ 1)....,....	+0.69
1294..	4.4	15.76	− 9,+10,....,− 1	15.25	(− 3,+ 3)....,....	+0.51
1294*a*.	4.3	17.24	(− 6,+ 6)....,....	16.81	(+ 7,− 7)....,....	+0.43
1294*b*.	4.1	17.38	(− 3,+ 4)....,....	17.05	(−12,+12)....,....	+0.33
1294*c*.	4.1	17.64:	(+ 1,− 1)....,....	17.12	(−14,+15)....,....	+0.52:
1296..	2.5	15.34	+16,− 9,− 7,....	15.18	(+ 7,− 6)....,....	+0.16
1296*a*.	2.5	15.81	(0, 0)....,....	15.84	(0, 0)....,....	−0.03
1296*b*.	2.7	17.45	(− 7,+ 7)....,....	17.20	(...., m)....,....	+0.25
1296*c*.	2.7	17.42	(− 4,+ 4)....,....	17.10	(...., m)....,....	+0.32
1299..	4.0	15.78	− 8,− 9,+17,+ 1	15.37	(− 5,+ 5)....,....	+0.41
1299*a*.	4.1	16.92	(− 2,+ 1)....,....	16.36	(− 9,+ 8)....,....	+0.56
1300..	2.7	15.98	+ 9,+ 6,−15,....	15.32	(− 5,− 4)....,+ 8	+0.66
1301..	3.4	15.35	−10,−10,....,+19	14.57	(− 4,+ 4)....,....	+0.78
1302..	2.9	16.84	− 2,+ 1,....,....	16.03	(−13,+13)....,....	+0.81
1303..	4.7	15.98	0,− 8,+ 7,....	15.00	(+10,− 6)....,− 3	+0.98
1303*a*.	4.4	16.22	(− 2,+ 1)....,....	15.52	(− 2,+ 1)....,....	+0.70
1304..	2.8	16.33	− 1,+ 1,....,....	15.61	(...., m)....,....	+0.72
1304*a*.	2.9	16.59	(−37,+37)....,....	16.08	(−15,+15)....,....	+0.51
1304*b*.	2.9	17.31	(−10,+21)....,....	16.96	(−12,+11)....,....	+0.42
1304*c*.	2.8	17.15	(−15,+15)....,....	16.64	(−14,+14)....,....	+0.51
1304*d**	2.9	17.38:	(−28,+27)....,....	17.17	(...., m)....,....	+0.21:
1305..	4.6	15.22	− 4,−13,+ 2,+15	14.50	(....,+ 4)− 5,....	+0.72
1306..	6.6	15.92	0,− 2,+ 3,....	15.50	(0, 0)....,....	+0.42
1307*a*.	3.3	17.38	(−13,+14)....,....	17.20	(+ 4,− 3)....,....	+0.18
1309..	3.4	16.07	+ 5,−12,+ 6,....	16.00	(−13,+13)....,....	+0.07
1309*a*	3.6	17.16	(+12,−11)....,....	17.00	(−21,+20)....,....	+0.16
1310..	3.0	15.48	−13,+13,....,....	14.64	(+ 4,− 6)+ 3,....	+0.84
1312..	4.1	16.11	− 4,− 7,....,+12	15.32	(+ 3,− 4)....,....	+0.79
1313..	3.0	14.90	− 3,− 1,+ 3,....	13.86	− 6,+ 7,− 1,....	+1.04
1313*a*.	2.9	16.98	(+ 6,− 5)....,....	16.68	(+16,−17)....,....	+0.30
1314..	10.5	15.86	− 3,+ 4,....,....	15.22	(−10,+11)....,....	+0.64
1315..	3.2	15.25	+ 4, 0,− 4,....	14.43	(+12,−12)....,....	+0.82
1315*a*.	3.4	17.34	(− 3,+ 3)....,....	16.90	(− 2,+ 1)....,....	+0.44
1316..	3.5	15.90	+ 2, 0,− 2,....	15.46	(+ 1, −1)....,....	+0.44
1318..	8.0	15.68	−22,− 3,+20,+ 4	15.72	(−11,+12)....,....	−0.04
1318*a*.	7.8	16.38	(−18,+17)....,....	15.82	(− 7,+ 8)....,....	+0.56
1319..	3.1	15.94	+ 4,+ 1,− 6,....	15.48	(−11,+ 2)....,+ 8	+0.46
1319*a*.	3.0	17.32	(−14,+14)....,....	17.02	(− 4,+ 5)....,....	+0.30

TABLE II—*Continued*

Number	Distance	Photographic		Photo-visual		Color-Index
		Mag.	Residuals	Mag.	Residuals	
1319b	3′.0	17.24	(− 3,+ 2)....,....	16.82	(−12,+13)....,....	+0.42
1322	6.7	15.62	+ 1,+11,−11,....	15.81	(− 6,+ 6)....,....	−0.19
1323	3.4	16.08	+ 4,− 4,....,....	15.24	(+ 1,− 2)....,....	+0.84
1324	5.5	15.64	− 1,+ 1,....,+ 1	15.74	(− 7,+ 7)....,....	−0.10
1324a	5.6	17.12	(− 2,+ 1)....,....	16.86	(− 2,+ 2)....,....	+0.26
1324b	5.5	16.99	(− 2,+ 2)....,....	16.63	(− 6,+ 6)....,....	+0.36
1324c	5.8	16.96	(+ 4,− 3)....,....	16.78	(− 3,+ 3)....,....	+0.18
1324d	6.2	17.31	(− 3,+ 3)....,....	16.98	(−19,+19)....,....	+0.33
1325	5.0	15.23	+ 9,− 6,− 2,....	14.45	....,...., m,....	+0.78
1327†	5.9	16.17	− 7,− 5,....,+11	15.49	(− 4,+ 4)....,....	+0.68
1329	3.4	15.93	+11,−11,....,....	15.50	(− 8,+ 9)....,....	+0.43
1329a	3.2	17.04	(+ 4,− 3)....,....	16.46	(0, 0)....,....	+0.58
1329b	3.2	17.32	(− 4,+ 5)....,....	17.15	(− 5,+ 5)....,....	+0.17
1331	9.3	15.89	+ 3,− 3,....,....	15.15	(− 7,+ 7)....,....	+0.74
1331a	9.5	16.06	(+ 6,− 5)....,....	15.46	(− 1,+ 1)....,....	+0.60
1332	5.1	15.60	−10,+13,....,− 2	14.82	(− 5,+ 6)....,....	+0.78
1333	3.9	16.48	−14,+15,....,....	15.74	(−10,+10)....,....	+0.74
1334	3.8	16.12	+ 3,− 4,....,....	15.40	(− 3,+ 2)....,....	+0.72
1335	3.5	15.60	− 6,+ 5,....,....	15.53	(− 8,+ 8)....,....	+0.07
1336	4.3	16.26	+ 1, 0,....,....	15.56	(− 1, 0)....,....	+0.70
1338	3.5	15.48	+15,−14,....,....	14.70	(− 8,− 9)....,+17	+0.78
1338a	3.6	17.40	(− 5,+ 6)....,....	17.14	(− 4,+ 3)....,....	+0.26
1339	5.9	15.90	+11,− 8,− 2,....	15.08	(0,+ 1)....,....	+0.82
1339a	5.6	17.30	(+18,− 9)....,....	16.96	(−17,+18)....,....	+0.34
1340	5.9	15.68	− 9,+ 9, 0,....	15.58	(− 3,+ 3)....,....	+0.10
1340a	6.5	17.07	(−10,+10)....,....	16.81	(+ 7,− 3)....,....	+0.26
1340b	6.4	17.08	(0,+ 1) ...,....	16.91	(−16,+16)....,....	+0.17
1342	5.2	15.03	+ 8,+ 2,−10,....	14.08	− 5,+13,− 7,.... (0,....)	+0.95
1343a*	10.1	16.17	(...., m)....,....	16.69	(...., m)....,....	−0.52
1343b	9.6	17.08	(0,+ 1)....,....	16.74	(− 4,+ 4)....,....	+0.34
1344*	4.2	16.48	−16,+15,....,....	16.98	(− 5,+ 5)....,....	−0.50
1344a*	4.2	.....	....,....,....,....	17.27	(...., m)....,....	......
1345	4.1	14.76	+ 7,− 7,....,....	13.62	− 9,....,+10,....	+1.14
1345a	4.4	17.16	(−19,+18)....,....	16.78	(+ 1, 0)....,....	+0.38
1346	10.0	11.80	+ 3,− 4,....,....	10.57	+36,− 5,−30,....	+1.23
1346a	9.6	16.92	(−16,+17)....,....	16.51	(−12,+12)....,....	+0.41
1346b	10.4	16.93	(− 3,+ 3)....,....	16.48	(−12,+12)....,....	+0.45
1347	5.5	15.48	− 9,− 1'....,+10	15.50	(+ 5,− 5)....,....	−0.02
1347a†	5.7	16.79	− 2,+ 2,....,....	16.38	(− 2,+ 3)....,....	+0.41
1350	4.1	15.89	+ 6,+ 1,+16,−24	15.29	(+ 1,− 1)....,....	+0.60
1352	4.4	15.97	+ 4,− 2,− 1,....	16.02	(−15,+14)....,....	−0.05
1352a	4.0	17.20	(− 2,+ 1)....,....	16.66	(−13,+12)....,....	+0.54
1354	9.0	16.02	+ 8,− 7,....,....	15.42	(− 2,+ 3)....,....	+0.60
1354a	9.0	17.20	(− 6,+ 6)....,....	16.76	(−23 +23)....,....	+0.44
1356*	6.8	16.22	0, 0,....,....	16.10	(+51,−51)....,....	+0.12
1360	4.4	14.73	+ 6,− 4,+ 2,− 5	13.69	−12,....,+12,....	+1.06
1360a	4.1	17.40	(− 2,+ 2)....,....	17.26	(− 4,+ 5)....,....	+0.14
1360b	4.0	17.22	(−14,+15)....,....	16.85	(−10,+10)....,....	+0.37
1361	9.8	16.86	−11,+12,....,....	16.91	(...., m)....,....	−0.05
1362	6.3	14.72	+ 3,−11,−10,+18	13.75	−10,+ 4,+ 6,....	+0.97

TABLE II—*Continued*

Number	Distance	Photographic Mag.	Photographic Residuals	Photo-visual Mag.	Photo-visual Residuals	Color-Index
1363	4′.5	15.21	+ 1,− 4,+ 2,....	14.45	....,...., m,....	+0.76
1363*a*	5.0	16.74	(− 4,+ 3)....,....	16.37	(− 1,+ 1)....,....	+0.37
1363*b*	4.9	17.17	(+ 4,− 4)....,....	16.56	(− 6,+ 7)....,....	+0.61
1364	4.7	15.96	− 7,−19,+18,+ 6	15.31	(−16,+16)....,....	+0.65
1364*a*	4.6	17.05	(+ 9,− 9)....,....	16.54	(+11,−10)....,....	+0.51
1365	4.7	15.64	+ 3,− 3,....,....	15.63	(+ 4,− 4)....,....	+0.01
1365*a*	5.2	16.98	(+ 2,− 2)....,....	16.62	(− 1,+ 1)....,....	+0.36
1365*b*	4.5	17.27	(+ 1,− 1)....,....	17.17	(...., m)....,....	+0.10
1366	9.6	15.85	− 2,−12,+ 3,+10	15.09	(+ 3,− 3)....,....	+0.76
1367	4.7	16.54	−12,+12,....,....	15.70	(− 1, 0)....,....	+0.84
1368	6.1	16.20	+ 2,− 2,....,....	15.54	(+ 1,− 1)....,....	+0.66
1369	5.0	15.94	+ 4,− 4,....,....	16.16	(− 4,+ 4)....,....	−0.22
1371	5.8	15.36	+ 7,− 7,....,....	15.32	(+ 5,− 4)....,....	+0.04
1371*a*	5.6	17.38	(− 7,+ 8)....,....	16.94	(−15,+16)....,....	+0.44
1372	5.6	15.27	+12,−22,− 5,+15	14.45	(+ 1,− 1)....,....	+0.82
1372*a*	5.7	16.42	(+13,−13)....,....	15.99	(−15,+14)....,....	+0.43
1372*b*†	6.6	16.43	+ 9,−12,....,+ 2	15.78	(−14,+15)....,....	+0.65
1373*a*	6.7	17.02	(+12,−13)....,....	17.04:	(m,....)....,....	−0.02:
1374	6.3	15.30	+ 5,−25,+11,+ 8	14.68	(− 2,+ 2)....,....	+0.62
1375	12.1	.....	....,....,....,....	12.68	....,...., m,....	.....
1376	5.9	14.63	+ 2,− 2,+ 1,....	13.52	− 5,− 4,+ 9,....	+1.11
1376*a*	5.1	15.66	(− 1,+ 1)....,....	15.72	(− 3,+ 4)....,....	−0.06
1376*b*	4.6	17.07	(−10,+10)....,....	16.63	(− 2,+ 2)....,....	+0.44
1377	5.5	16.55	−11,+11,....,....	15.76	(− 7,+ 8)....,....	+0.79
1378	6.2	16.02	− 1,+ 2,....,....	15.52	(− 2,+ 1)....,....	+0.50
1379	5.6	16.68	+ 4,− 5,....,....	16.00	(−13,+13)....,....	+0.68
1380*a*	7.7	16.08	(+ 1, 0)....,....	15.46	(+ 7,− 7)....,....	+0.62
1381	5.6	16.54	− 4,+ 3,....,....	15.84	(− 3,+ 3)....,....	+0.70
1382	5.7	16.01	+ 6,−11,+ 4,....	15.53	(0, 0)....,....	+0.48
1383	8.3	15.04	+15,−15,....,....	13.91	....,...., m,....	+1.13
1383*a*	8.2	16.99	(+ 1,− 1)....,....	16.13	(−13,+13)....,....	+0.86
1385	7.4	16.24	+ 6,− 6,....,....	15.50	(0, 0)....,....	+0.74
1386*a*	5.6	17.00	(0,+ 1),....,....	16.56	(−13,+13)....,....	+0.44
1387	9.6	15.56	−10,+ 9,....,....	14.96	(−11,+10)....,....	+0.60
1388*a*	6.8	17.00	(0, 0)....,....	16.36	(0,− 1)....,....	+0.64
1389	9.6	15.58	− 8,+ 7,....,....	.....	....,....,....,....	.....
1390	6.0	15.85	+13,− 8,+15,−20	15.46	(− 6,+ 7)....,....	+0.39
1391	6.1	15.12	− 1,− 7, 0,+ 9	14.13	(....,+ 9)− 9,....	+0.99
1391*a*	6.4	16.90	(0,− 1)....,....	16.32	(− 2,+ 3)....,....	+0.58
1391*b*	6.1	17.02	(+ 6,− 6)....,....	16.72	(− 2,+ 3)....,....	+0.30
1392	8.1	14.14	−16,−11,+11,+18	12.92	−12,+ 7,+ 4,....	+1.22
1392*a*	7.5	17.01	(− 8,+ 8)....,....	16.82	(− 7,+ 6)....,....	+0.19
1393	6.5	15.57	+ 3,− 1,− 2,....	15.53	(− 8,+ 8)....,....	+0.04
1393*a*	6.6	16.80	(+ 6,− 7)....,....	16.48	(− 9,+10)....,....	+0.32
1393*b*	6.5	17.24	(−10,+10)....,....	16.80	(−10,+11)....,....	+0.44
1393*c*	6.4	16.68	(− 6,+ 5)....,....	16.38	(+ 1, 0)....,....	+0.30
1393*d*	6.0	17.45	(m,....)....,....	.....	....,....,....,....	.....
1396	9.9	16.07	+ 3,− 3,....,....	15.36	(− 4,+ 3)....,....	+0.71
1396*a*	9.2	16.86	(0, 0)....,....	16.61	(−11,+11)....,....	+0.25
1396*b*	9.1	16.96	(+ 1, 0)....,....	16.69	(...., m)....,....	+0.27
1397	7.4	14.29	− 7,+ 2,+ 4,....	12.60	− 6,−11,+17,....	+1.69
1397*a*	7.1	16.90	(− 4,+ 3)....,....	16.58	(− 1, 0)....,....	+0.32

TABLE II—*Continued*

Number	Distance	Photographic Mag.	Photographic Residuals	Photo-visual Mag.	Photo-visual Residuals	Color Index
1401..	8'.8	15.32	− 7,+ 6,....,....	15.44	(− 2,+ 1)....,....	−0.12
1402..	9.6	13.44	−29,+30,....,....	12.78	....,...., m,....	+0.66
1403..	10.6	16.60	− 6,+ 6,....,....	16.14	(− 5,+ 6)....,....	+0.46
1403*a*.	10.5	16.96	(+ 1, 0)....,....	16.60	(−21,+20)....,....	+0.36
1405..	7.1	16.26	−11,+11,....,....	15.47	(0, 0)....,....	+0.79
1405*a*.	6.8	17.10	(−10,+11)....,....	16.61	(− 8,+ 8)....,....	+0.49
1408..	9.6	15.91	+ 1,− 1,....,....	15.12	(− 4,+ 5)....,....	+0.79
1408*a*.	9.2	17.01	(...., m)....,....	16.35	(...., m)....,....	+0.66
1412..	7.6	15.72	+ 4,− 3,....,....	14.87	(+ 5,− 5)....,....	+0.85
1412*a*.	8.6	16.82	(− 3,+ 3)....,....	16.48	(− 2,+ 3)....,....	+0.34
1412*b*.	8.1	16.98	(+ 2,− 2)....,....	16.78	(−17,+17)....,....	+0.20
1413..	7.7	15.68	+ 5,−11,+21,−13	15.50	(+ 3,− 3)....,....	+0.18
1417..	9.6	16.24	−17,+17,....,....	15.82	(−13,+14)....,....	+0.42
1417*a*.	9.4	16.66	(− 4,+ 4)....,....	16.20	(− 8,+ 9)....,....	+0.46
1418..	8.3	15.44	− 5,−10,+14,....	14.55	(+ 1,− 1)....,....	−0.11
1420..	9.4	14.92	+ 6,− 7,+ 1,....	14.14	(+12,−11)....,....	+0.78
1422*b*.	8.3	17.10	(−10,+11)....,....	16.81	(...., m)....,....	+0.29
1422*c*.	8.5	16.70	(+ 9,− 8)....,....	16.34	(−10,+10)....,....	+0.36
1423..	10.0	15.01	0, 0,....,....	14.35	(+ 7,− 7)....,....	+0.66
1426..	9.7	15.28	+15,−23,+ 9,....	14.55	(+ 9,− 9)....,....	+0.73
1426*a*.	8.8	16.72	(0,+ 1)....,....	16.25	(− 1,+ 1)....,....	+0.47
1429..	10.4	15.73	−13,+13,....,....	15.38	(− 1,+ 1)....,....	+0.35
1433..	9.5	16.30	+ 4,− 4,....,....	15.72	(− 3,+ 4)....,....	+0.58
1435..	9.6	15.92	+ 9,−10,....,....	15.36	(+ 4,− 3)....,....	+0.56
1437..	10.7	12.10	+12,−28,+13,+ 2	11.75	(− 7,+ 7)....,....	+0.35
1439..	10.7	13.61	−26,+10,+16,....	12.86	(−11,+10)....,....	+0.75
1441..	10.5	16.75	−19,+19,....,....	15.93	(0, 0)....,....	+0.82
1441*a*.	10.6	16.98	(+ 6,− 5)....,....	16.64	(−11,+11)....,....	+0.34
1448..	11.3	16.70	+ 2,− 1,....,....	16.32	(−26,+26)....,....	+0.38
1449..	11.3	14.18	−14,+13,....,....	12.78	− 9,....,....,.... (+ 9,....)	+1.40

TABLE III

CO-ORDINATES OF POSTSCRIPT STARS (1900.0)

No.	R.A.	Decl.	No.	R.A.	Decl.
	13^h	28°		13^h	28°
157*a*....	$36^m50^s.9$	54′ 58″	290*b*...	$37^m26^s.4$	60′ 36″
157*b*....	36 55.1	54 30	291*a*...	37 21.1	52 47
157*c*....	36 55.1	54 40	291*b*...	37 19.4	52 55
164*a*....	36 55.2	52 58	291*c*...	37 20.8	52 54
164*b*....	36 52.8	52 37	296*a*...	37 20.8	52 15
164*c*....	36 52.0	52 37	296*b*...	37 20.0	52 19
168*a*....	37 0	57 56	301*a*...	37 23.3	56 29
175*a*....	36 57.7	50 20	301*b*...	37 22.4	56 39
177*a*....	37 1.8	51 23	301*c*...	37 21.7	57 4
177*b*....	37 4.2	51 9	301*d*...	37 20.8	57 5
179*a*....	37 1.6	52 38	303*a*...	37 22.0	52 41
180*a*....	37 56.2	45 52	305*a*...	37 23.0	49 9
180*b*....	36 58.8	45 53	307*a*...	37 22.6	50 4
181*a*....	37 2.3	54 26	307*b*...	37 22.1	50 0
181*b*....	37 0.7	55 26	308*a*...	37 24.2	51 38
181*c*....	36 59.2	55 17	308*b*...	37 20.8	51 33
188*a*....	37 7.6	49 18	310*a*...	37 22.7	51 58
188*b*....	37 2.1	49 38	311*a*...	37 23.8	50 27
188*c*....	37 6.4	50 35	311*b*...	37 23.9	50 32
188*d*....	37 8.0	50 29	320*a*...	37 21.1	47 31
190*a*....	37 7.2	54 49	320*b*...	37 21.0	47 24
193*a*....	37 7.4	59 52	322*a*...	37 22.7	51 51
205*a*....	37 10.0	55 10	326*a*...	37 22.8	54 12
206*a*....	37 9.6	57 53	326*b*...	37 22.8	54 19
208*a*....	37 6.7	47 25	326*c*...	37 22.6	54 28
210*a*....	37 10.0	53 58	332*a*...	37 23.7	56 4
210*b*....	37 10.0	54 8	332*b*...	37 23.2	55 44
211*a*....	37 10.3	52 23	336*a*...	37 23.6	51 16
211*b*....	37 11.9	52 12	345*a*...	37 24.1	50 55
212*a*....	37 12.4	55 56	348*a*...	37 25.2	53 25
212*b*....	37 11.7	56 21	350*a*...	37 25.2	54 44
215*a*....	37 10.6	52 49	355*a*...	37 25.1	52 0
230*a*....	37 12.3	60 52	360*a*...	37 25.3	52 54
230*b*....	37 11.6	61 1	360*b*...	37 25.3	52 51
230*c*....	37 11.3	61 15	360*c*...	37 25.3	52 44
238*a*....	37 15.5	52 55	360*d*...	37 24.8	52 56
238*b*....	37 14.7	52 55	364*a*...	37 25.7	53 14
247*a*....	37 17.1	53 37	376*a*...	37 26.4	53 20
249*a*....	37 15.4	55 17	378*a*...	37 27.6	49 19
249*b*....	37 14.7	55 14	379*a*...	37 27.0	51 18
250*a*....	37 16.0	49 30	379*c*...	37 27.3	51 10
251*a*....	37 16.8	51 10	380*a*...	37 26.1	53 33
253*a*....	37 15.3	55 52	380*b*...	37 25.7	53 41
255*a*....	37 18.1	56 55	381*a*...	37 27.2	53 58
258*a*....	37 18.4	54 48	381*b*...	37 27.4	53 59
260*a*....	37 18.5	52 15	385*a*...	37 26.9	51 44
261*a*....	37 18.4	48 12	385*b*...	37 27.2	51 54
262*a*....	37 17.2	50 12	386*a*...	37 26.7	49 56
281*a*....	37 20.7	56 8	387*a*...	37 27.3	54 9
290*a*....	37 21.5	60 21	394*a*...	37 26.9	53 7

TABLE III—*Continued*

No.	R.A.	Decl.	No.	R.A.	Decl.
	13^h	$28°$		13^h	$28°$
396*a*....	$37^m27^s.6$	55′ 4″	640*a*...	$37^m32^s.8$	49′ 56″
397*a*....	37 27.8	52 53	640*b*...	37 32.4	49 49
403*a*....	37 27.4	52 38	640*c*...	37 33.2	49 52
403*b*....	37 27.2	52 37	640*d*...	37 33.3	49 47
403*c*....	37 27.9	52 43	640*e*...	37 33.6	49 41
403*d*....	37 27.2	52 29	640*f*...	37 32.4	50 6
403*e*....	37 27.5	52 31	649*a*...	37 32.8	48 34
403*f*....	37 27.7	52 33	649*b*...	37 32.5	48 34
403*g*....	37 27.9	52 34	649*c*...	37 33.7	49 4
411*a*....	37 28.3	48 19	665*a*...	37 33.3	50 48
417*a*....	37 28.0	52 15	680*a*...	37 33.0	54 24
417*b*....	37 27.7	52 20	680*b*...	37 32.5	54 27
417*c*....	37 27.5	52 12	680*c*...	37 33.0	54 30
417*d*....	37 26.8	52 10	700*a*...	37 33.5	50 29
418*a*....	37 28.4	51 25	701*a*...	37 33.7	58 52
419*a*....	37 28.5	55 3	701*b*...	37 31.3	57 59
422*a*....	37 28.8	51 0	701*c*...	37 31.0	57 50
425*a*....	37 27.9	53 54	701*d*...	37 30.7	57 49
452*a*....	37 27.8	54 15	713*a*...	37 37.1	43 46
452*b*....	37 27.8	54 26	730*a*...	37 34.1	51 16
452*c*....	37 29.2	51 14	739*a*...	37 31.4	57 30
455*a*....	37 28.8	58 27	739*b*...	37 35.1	57 63
467*a*....	37 30.6	55 18	740*a*...	37 35.4	49 34
467*b*....	37 30.5	55 22	740*b*...	37 35.0	49 35
471*a*....	37 29.4	49 34	758*a*...	37 34.3	51 10
480*a*....	37 30.1	56 22	759*a*...	37 34.1	55 7
480*b*....	37 30.0	56 46	801*a*...	37 35.0	51 24
482*a*....	37 30.2	51 2	801*b*...	37 35.8	51 24
482*b*....	37 30.9	51 1	801*c*...	37 36.3	51 20
499*a*....	37 27.5	55 59	837*b*...	37 36.5	56 49
499*b*....	37 25.1	56 10	845*a*...	37 36.2	51 4
499*c*....	37 24.9	56 19	885*a*...	37 35.5	51 4
499*d*....	37 24.8	56 4	900*a*...	37 36.8	50 32
499*e*....	37 24.9	56 2	900*b*...	37 36.3	50 26
499*f*....	37 25.1	56 4	902*a*...	37 36.0	55 16
499*g*....	37 24.4	56 8	902*b*...	37 35.7	55 12
499*h*....	37 24.3	56 8	925*a*...	37 36.4	50 6
502*a*....	37 30.5	50 46	925*b*...	37 37.1	49 59
513*a*....	37 31.1	55 3	925*c*...	37 36.8	49 54
522*a*....	37 30.5	55 53	925*d*...	37 36.6	50 1
522*b*....	37 30.2	55 40	925*e*...	37 38.2	50 3
522*c*....	37 30.0	55 44	926*a*...	37 36.8	57 5
550*a*....	37 32.1	54 39	945*a*...	37 37.6	51 20
573*a*....	37 32.3	56 8	945*b*...	37 38.1	51 15
590*a*....	37 32.0	56 29	974*a*...	37 35.1	45 48
595*b*....	37 30.3	60 10	1000*a*..	37 37.5	55 36
605*a*....	37 32.6	50 36	1022*a*..	37 38.3	50 55
609*a*....	37 32.0	56 51	1028*a*..	37 38.4	55 4
609*b*....	37 32.5	57 9	1028*b*..	37 37.8	55 4
621*a*....	37 34.2	56 4	1028*c*..	37 37.4	55 5
621*b*....	37 33.9	56 5	1076*a*..	37 39.2	51 14
621*d*....	37 32.4	55 58	1090*a*..	37 39.5	54 45
628*a*....	37 32.3	51 22	1090*b*..	37 40.0	54 54

TABLE III—*Continued*

No.	R.A.	Decl.	No.	R.A.	Decl.
	13^h	$28°$		13^h	$28°$
1090*c*...	$37^m39^s.5$	54′ 58″	1227*c*..	$37^m42^s.2$	49′ 9″
1120*a*...	37 40.8	51 0	1227*d*..	37 41.7	49 25
1123*a*...	37 39.7	50 38	1236*a*..	37 43.6	52 34
1123*b*...	37 39.1	50 32	1242*a*..	37 44.4	52 11
1123*c*...	37 38.7	50 36	1243*a*..	37 46.3	54 53
1127*a*...	37 40.9	54 7	1244*a*..	37 44.6	53 29
1128*a*...	37 39.8	56 10	1247*a*..	37 45.5	53 42
1128*b*...	37 41.2	55 58	1247*b*..	37 45.2	53 42
1128*c*...	37 42.6	56 21	1250*a*..	37 44.0	58 15
1131*a*...	37 39.5	56 50	1254*a*..	37 44.3	45 47
1131*b*...	37 38.7	56 44	1261*a*..	37 45.9	50 29
1140*a*...	37 39.9	57 15	1265*a*..	37 43.8	55 44
1140*b*...	37 39.8	57 2	1265*b*..	37 43.1	55 49
1140*c*...	37 43.4	57 0	1265*c*..	37 42.6	55 54
1140*d*...	37 44.9	56 48	1265*d*..	37 43.0	55 59
1149*a*...	37 41.0	54 20	1265*e*..	37 45.8	55 46
1149*b*...	37 40.6	54 19	1265*f*...	37 45.3	55 45
1149*c*...	37 41.8	54 24	1265*g*..	37 45.8	55 34
1149*d*...	37 41.2	54 28	1270*a*..	37 45.8	58 49
1149*e*...	37 42.1	54 29	1270*b*..	37 46.7	58 46
1149*f*...	37 43.7	54 16	1271*a*..	37 46.3	54 13
1149*g*...	37 43.5	54 19	1278*a*..	37 45.8	53 1
1154*a*...	37 41.4	54 59	1280*a*..	37 45.5	50 51
1172*a*...	37 41.0	55 33	1280*b*..	37 45.1	50 55
1172*b*...	37 41.1	55 29	1283*a*..	37 46.7	51 54
1172*c*...	37 41.0	55 34	1285*a*..	37 47.8	54 22
1175*a*...	37 41.4	50 37	1285*b*..	37 47.8	54 28
1178*a*...	37 40.7	48 4	1287*a*..	37 46.6	49 19
1178*b*...	37 42.8	48 20	1289*a*..	37 46.2	54 54
1178*c*...	37 42.7	47 48	1290*a*..	37 47.4	51 30
1178*d*...	37 41.8	47 40	1290*b*..	37 47.0	51 28
1181*a*...	37 42.6	55 28	1292*a*..	37 46.6	52 51
1181*b*...	37 42.7	55 31	1292*b*..	37 46.7	52 53
1201*a*...	37 41.4	49 35	1293*b*..	37 48.0	50 11
1201*b*...	37 41.0	49 34	1293*c*..	37 48.4	50 20
1201*c*...	37 41.4	49 38	1294*a*..	37 47.4	56 16
1201*d*...	37 41.1	49 39	1294*b*..	37 46.9	56 6
1205*a*...	37 43.3	51 24	1294*c*..	37 47.1	56 1
1206*a*...	37 42.8	53 36	1296*a*..	37 46.2	52 17
1206*b*...	37 42.3	53 43	1296*b*..	37 47.2	52 20
1206*c*...	37 42.5	53 46	1296*c*..	37 47.4	52 23
1218*a*...	37 43.5	51 11	1299*a*..	37 48.1	55 50
1218*b*...	37 43.2	51 18	1303*a*..	37 48.1	49 26
1222*a*...	37 43.5	53 50	1304*a*..	37 48.2	53 26
1222*b*...	37 43.9	53 51	1304*b*..	37 47.5	53 24
1222*c*...	37 44.0	53 59	1304*c*..	37 48.0	53 12
1223*a*...	37 43.0	57 40	1304*d*..	37 48.4	53 16
1223*b*...	37 44.0	57 52	1307*a*..	37 47.6	54 42
1225*a*...	37 44.3	53 18	1309*a*..	37 48.8	50 51
1225*b*...	37 43.9	53 22	1313*a*..	37 48.4	52 36
1225*c*...	37 43.7	53 9	1315*a*..	37 48.9	51 26
1227*a*...	37 43.8	49 16	1318*a*..	37 48.9	60 5
1227*b*...	37 44.1	49 20	1319*a*..	37 49.0	52 26

TABLE III—*Continued*

No.	R.A.	Decl.	No.	R.A.	Decl.
	13^h	28°		13^h	28°
1319*b*...	$37^m48^s.8$	52′ 31″	1372*a*..	$37^m59^s.3$	54′ 55″
1324*a*...	37 49.0	57 33	1372*b*..	38 1.2	56 11
1324*b*...	37 47.3	57 37	1373*a*..	37 58.4	57 7
1324*c*...	37 48.0	58 0	1376*a*..	37 55.7	50 36
1324*d*...	37 49.0	58 15	1376*b*..	37 54.0	50 51
1329*a*...	37 49.4	53 23	1380*a*..	38 1.3	48 1
1329*b*...	37 49.5	53 31	1383*a*..	37 56.8	46 13
1331*a*...	37 48.4	43 42	1386*a*..	38 0.8	53 8
1338*a*...	37 51.3	52 16	1388*a*..	38 0.3	49 1
1339*a*...	37 50.5	48 19	1391*a*..	38 4.1	53 45
1340*a*...	37 53.9	47 49	1391*b*..	38 2.0	54 39
1340*b*...	37 54.8	48 13	1392*a*..	38 1.1	57 44
1343*a*...	37 44.4	42 57	1393*a*..	38 3.7	50 51
1343*b*...	37 44.0	43 29	1393*b*..	38 3.1	50 46
1344*a*...	37 52.4	54 52	1393*c*..	38 3.4	51 16
1345*a*...	37 53.9	54 34	1393*d*..	38 1.9	51 31
1346*a*...	37 53.9	61 45	1396*a*..	38 4.2	59 53
1346*b*...	37 55.6	62 20	1396*b*..	38 2.8	60 1
1347*a*...	37 54.7	56 35	1397*a*..	38 4.9	50 5
1352*a*...	37 53.2	53 32	1403*a*..	38 5.2	61 7
1354*a*...	37 52.7	44 36	1405*a*..	38 6.4	53 16
1360*a*...	37 54.1	53 2	1408*a*..	38 8.2	59 3
1360*b*...	37 53.2	52 57	1412*a*..	38 13.1	55 20
1363*a*...	37 57.6	53 21	1412*b*..	38 9.2	56 16
1363*b*...	37 57.2	53 29	1417*a*..	38 12.1	58 1
1364*a*...	37 55.2	54 1	1422*b*..	38 12.6	51 3
1365*a*...	37 58.4	51 56	1422*c*..	38 13.6	51 34
1365*b*...	37 55.2	51 59	1426*a*..	38 13.0	49 36
1371*a*...	37 54.0	56 12	1441*a*..	38 21.8	56 10

TABLE IV
PHOTOGRAPHIC RESIDUALS

	Plate Number						
	2463	2506	3679	3680	3846	3847	All
Number of Magnitudes.....	466	465	186	188	332	332	1969
Systematic Deviation.......	0.00	+0.02	−0.05	0.00	−0.03	+0.03	0.00
Average Deviation.......	±0.08	±0.08	±0.11	±0.07	±0.06	±0.06	±0.075

TABLE V
PHOTO-VISUAL RESIDUALS

	Plate Number						
	2371	2462	2505	3684	3774	3775	All
Number of Magnitudes.....	64	80	85	39	661	661	1569
Systematic Deviation.......	−0.01	−0.01	+0.01	0.00	−0.02	+0.02	0.00
Average Deviation.......	±0.07	±0.05	±0.06	±0.07	±0.067	±0.067	±0.066

TABLE VI
COMPARISON STARS

Designation		Photographic Magnitude		Color-Index
Bailey	Von Zeipel	Harvard	Mt. Wilson	
a............	740	13.50	14.04	+0.70
b............	238	13.58	14.05	+1.79
c............	640	13.98	14.57	+1.18
d............	263	14.22	14.53	+1.12
e............	250	14.50	14.81	+0.90
f............	218	14.98	15.06	+0.53
g............	227	15.28	15.22	+0.65
*h**...........	258	15.70	15.53	−0.02
k............	609	16.00	15.63	−0.04
l............	1131	16.23	15.83	+0.33
m............	1055	16.49	15.94	+0.69
n............	1327	16.82	16.16	+0.68
o............	1372*b*	17.15	16.37	+0.65
p............	1347*a*	17.63	16.84	+0.41

TABLE VII

COLOR-CLASS AND DISTANCE

Distance	Tabulated Quantity	Color-Class						All Colors
		b	a	f	g	k	m	
1′.3 to 1′.5	No. Stars....	0	1	2	4	0	0	7
	Av. C. I.....	....	+0.12	+0.53	+1.00	....	....	+0.74
	Av. Pv. mag.	....	15.47	15.24	13.98	....	....	14.55
1′.6......	No. stars....	2	4	4	9	2	0	21
	Av. C. I.....	−0.09	+0.13	+0.68	+0.98	+1.26	....	+0.69
	Av. Pv. mag.	16.18	15.51	16.05	14.86	13.40	....	15.20
1′.7......	No. stars....	2	4	5	3	0	0	14
	Av. C. I.....	−0.10	+0.23	+0.67	+0.93	....	....	+0.49
	Av. Pv. mag.	15.70	16.07	15.63	15.37	....	....	15.71
1′.8......	No. stars....	0	2	9	10	1	0	22
	Av. C. I.....	....	+0.06	+0.68	+0.93	+1.22	....	+0.77
	Av. Pv. mag.	....	15.59	15.76	15.21	13.18	....	15.38
1′.9......	No. stars....	2	3	9	8	2	0	24
	Av. C. I.....	−0.10	+0.25	+0.66	+0.88	+1.30	....	+0.67
	Av. Pv. mag.	15.96	15.22	15.77	15.37	12.96	....	15.35
2′.0......	No. stars....	0	3	11	5	2	1	22
	Av. C. I.....	....	+0.17	+0.64	+0.92	+1.26	+1.80	+0.75
	Av. Pv. mag.	....	15.80	15.87	14.93	13.62	12.33	15.28
2′.1......	No. stars....	3	5	16	13	0	0	37
	Av. C. I.....	−0.06	+0.19	+0.65	+0.89	....	....	+0.62
	Av. Pv. mag.	16.32	15.86	16.20	15.17	....	....	15.80
2′.2......	No. stars....	0	7	9	5	0	0	21
	Av. C. I.....	....	+0.20	+0.59	+1.00	....	....	+0.56
	Av. Pv. mag.	....	16.02	15.96	14.96	....	....	15.74
2′.3......	No. stars....	0	1	11	6	0	0	18
	Av. C. I.....	....	+0.35	+0.64	+0.93	....	....	+0.72
	Av. Pv. mag.	....	16.92	16.08	14.68	....	....	15.66
2′.4......	No. stars....	1	3	14	6	0	0	24
	Av. C. I.....	−0.06	+0.08	+0.61	+0.94	....	....	+0.60
	Av. Pv. mag.	15.60	15.70	16.03	15.00	....	....	15.71
2′.5......	No. stars....	3	2	10	3	0	0	18
	Av. C. I.....	−0.10	+0.08	+0.65	+0.97	....	....	+0.52
	Av. Pv. mag.	15.76	15.35	16.12	14.24	....	....	15.66
2′.6......	No. stars....	0	2	3	4	0	0	9
	Av. C. I.....	....	+0.16	+0.65	+0.94	....	....	+0.67
	Av. Pv. mag.	....	15.36	15.50	14.78	....	....	15.15
2′.7......	No. stars....	0	2	6	8	1	0	17
	Av. C. I.....	....	+0.18	+0.67	+1.02	+1.32	....	+0.81
	Av. Pv. mag.	....	16.10	15.96	14.50	13.08	....	15.12

TABLE VII—*Continued*

Distance	Tabulated Quantity	Color-Class						All Colors
		b	*a*	*f*	*g*	*k*	*m*	
2′.8	No. stars	1	1	13	4	2	0	21
	Av. C. I.	−0.04	+0.01	+0.65	+0.95	+1.29	......	+0.71
	Av. Pv. mag.	15.53	15.96	15.85	14.92	13.12	......	15.41
2′.9	No. stars	0	4	8	3	1	10	16
	Av. C. I.	......	+0.21	+0.62	+0.90	+1.21	......	+0.60
	Av. Pv. mag.	......	16.19	16.11	14.89	13.57	......	15.74
3′.0	No. stars	0	3	15	5	2	......	25
	Av. C. I.	......	+0.15	+0.60	+0.95	+1.26	......	+0.67
	Av. Pv. mag.	......	16.14	16.49	14.52	13.09	......	15.78
3′.1	No. stars	0	2	7	2	0	0	11
	Av. C. I.	......	+0.18	+0.57	+1.00	......	......	+0.58
	Av. Pv. mag.	......	16.27	15.83	14.29	......	......	15.63
3′.2	No. stars	0	3	6	3	0	0	12
	Av. C. I.	......	+0.27	+0.63	+0.85	......	......	+0.60
	Av. Pv. mag.	......	15.89	15.84	15.34	......	......	15.73
3′.3	No. stars	0	0	6	1	0	0	7
	Av. C. I.	......	......	+0.64	+0.84	......	......	+0.66
	Av. Pv. mag.	......	......	15.79	14.40	......	......	15.59
3′.4	No. stars	0	2	14	1	0	0	17
	Av. C. I.	......	+0.22	+0.56	+0.84	......	......	+0.54
	Av. Pv. mag.	......	15.88	15.84	15.24	......	......	15.81
3′.5	No. stars	1	3	7	4	0	0	15
	Av. C. I.	−0.18	+0.15	+0.60	+0.84	......	......	+0.52
	Av. Pv. mag.	16.42	15.99	15.70	15.24	......	......	15.68
3′.6 and 3′.7	No. stars	2	2	8	1	0	0	13
	Av. C. I.	−0.34	+0.36	+0.62	+0.93	......	......	+0.46
	Av. Pv. mag.	15.10	16.94	15.71	14.96	......	......	15.75
3′.8 and 3′.9	No. stars	0	1	12	3	1	0	17
	Av. C. I.	......	+0.36	+0.61	+0.84	+1.36	......	+0.68
	Av. Pv. mag.	......	15.46	15.97	15.40	12.47	......	15.64
4′.0 and 4′.1	No. stars	2	7	16	4	0	0	29
	Av. C. I.	−0.06	+0.29	+0.54	+1.02	......	......	+0.51
	Av. Pv. mag.	15.73	16.36	16.31	13.91	......	......	15.95
4′.2 and 4′.3	No. stars	1	4	5	0	0	0	10
	Av. C. I.	−0.02	+0.33	+0.60	......	......	......	+0.43
	Av. Pv. mag.	15.54	16.42	16.18	......	......	......	16.21
4′.4 and 4′.5	No. stars	1	4	9	5	0	1	20
	Av. C. I.	−0.05	+0.28	+0.54	+0.92	......	+1.79	+0.61
	Av. Pv. mag.	16.02	16.52	15.80	14.73	......	12.48	15.52

TABLE VII—*Continued*

Distance	Tabulated Quantity	Color-Class						All Colors
		b	*a*	*f*	*g*	*k*	*m*	
4′.6 and 4′.7	No. stars	0	2	10	2	0	0	14
	Av. C. I.	....	+0.02	+0.61	+0.91	....	....	+0.57
	Av. Pv. mag.	....	15.63	15.66	15.35	....	....	15.61
4′.8 and 4′.9	No. stars	0	2	4	2	0	0	8
	Av. C. I.	....	+0.22	+0.59	+1.06	....	....	+0.62
	Av. Pv. mag.	....	16.06	16.30	13.91	....	....	15.64
5′.0 and 5′.1	No. stars	2	5	8	3	0	0	18
	Av. C. I.	−0.14	+0.28	+0.66	+0.95	....	....	+0.52
	Av. Pv. mag.	15.94	16.50	15.54	14.49	....	....	15.68
5′.2 and 5′.3	No. stars	0	2	7	3	0	0	12
	Av. C. I.	....	+0.36	+0.58	+0.91	....	....	+0.62
	Av. Pv. mag.	....	16.70	16.13	14.24	....	....	15.75
5′.4 and 5′.5	No. stars	3	5	6	2	0	0	16
	Av. C. I.	−0.08	+0.35	+0.59	+0.80	....	....	+0.42
	Av. Pv. mag.	15.59	16.22	15.83	15.94	....	....	15.92
5′.6 and 5′.7	No. stars	0	4	14	3	0	0	21
	Av. C. I.	....	+0.30	+0.56	+0.89	....	....	+0.56
	Av. Pv. mag.	....	16.09	16.01	14.84	....	....	15.86
5′.8 and 5′.9	No. stars	0	3	3	2	0	0	8
	Av. C. I.	....	+0.32	+0.60	+0.96	....	....	+0.51
	Av. Pv. mag.	....	15.89	15.65	14.30	....	....	15.40
6′.0 and 6′.1	No. stars	0	3	5	2	0	0	10
	Av. C. I.	....	+0.32	+0.63	+0.93	....	....	+0.60
	Av. Pv. mag.	....	15.84	15.85	14.00	....	....	15.48
6′.2 and 6′.3	No. stars	0	4	7	3	0	0	14
	Av. C. I.	....	+0.23	+0.63	+0.97	....	....	+0.59
	Av. Pv. mag.	....	16.40	15.82	13.42	....	....	15.47
6′.4 and 6′.5	No. stars	1	7	5	1	0	0	14
	Av. C. I.	−0.58	+0.23	+0.56	+0.99	....	....	+0.35
	Av. Pv. mag.	16.32	16.40	16.06	13.86	....	....	16.09
6′.6 to 7′.0	No. stars	1	5	10	2	0	0	18
	Av. C. I.	−0.19	+0.23	+0.52	+0.90	....	....	+0.44
	Av. Pv. mag.	15.81	15.74	15.92	14.32	....	....	15.69
7′.1 to 7′.5	No. stars	1	6	7	3	1	1	19
	Av. C. I.	−0.03	+0.20	+0.65	+0.90	+1.32	+1.69	+0.60
	Av. Pv. mag.	15.38	15.92	15.63	13.43	12.82	12.60	15.05
7′.6 to 8′.0	No. stars	2	5	8	3	0	0	18
	Av. C. I.	−0.04	+0.20	+0.57	+0.99	....	....	+0.47
	Av. Pv. mag.	15.73	15.71	15.73	14.43	....	....	15.51

TABLE VII—*Continued*

Distance	Tabulated Quantity	Color-Class						All Colors
		b	a	f	g	k	m	
8′.1 to 8′.5	No. stars	1	5	6	3	1	0	16
	Av. C. I.	−0.11	+0.27	+0.60	+0.97	+1.22	....	+0.56
	Av. Pv. mag.	14.55	16.22	15.70	14.89	12.92	....	15.46
8′.6 to 9′.0	No. stars	1	2	9	2	0	0	14
	Av. C. I.	−0.12	+0.32	+0.55	+0.98	....	....	+0.53
	Av. Pv. mag.	15.44	16.56	15.74	15.00	....	....	15.73
9′.1 to 9′.5	No. stars	0	1	12	4	0	0	17
	Av. C. I.	....	+0.25	+0.65	+0.92	....	....	+0.69
	Av. Pv. mag.	....	16.61	15.64	14.88	....	....	15.52
9′.6 to 10′.0	No. stars	2	1	16	5	1	0	25
	Av. C. I.	−0.04	+0.34	+0.59	+0.99	+1.23	....	+0.64
	Av. Pv. mag.	16.22	16.74	15.34	14.59	10.57	....	15.12
10′.1 to 11′.4	No. stars	2	9	6	3	1	0	21
	Av. C. I.	−0.10	+0.32	+0.58	+1.03	+1.40	....	+0.51
	Av. Pv. mag.	15.72	15.16	14.98	15.15	12.78	....	15.05

TABLE VIII

Frequency of Photo-visual Magnitudes for Each Color-Class

DISTANCE FROM CENTER $1'.3$ TO $1'.9$

Limits of Photo-visual Magnitude	<*b*5	*b*5 to *a*0	*a*0 to *a*5	*a*5 to *f*0	*f*0 to *f*5	*f*5 to *g*0	*g*0 to *g*5	*g*5 to *k*0	*k*0 to *k*5	>*k*5	All Colors
12.60–.79									1	1	2
.80–.99							1	2			3
13.00–.19									1		1
.20–.39									1		1
.40–.59											
.60–.79								2			2
.80–.99								1			1
14.00–.19									1		1
.20–.39											
.40–.59				1			2				3
.60–.79						2	1				3
.80–.99						1	2				3
15.00–.19					1	2	3	1			7
.20–.39		1	1		3	1	5	1			12
.40–.59		1	4	2	1	3	4	1			16
.60–.79		1	3	1		4	3				12
.80–.99						2	1				3
16.00–.19		1		1			2				4
.20–.39					1	2	1				4
.40–.59		1				2	1				4
.60–.79		1				2					3
.80–.99				1	1	1					3
Total	0	6	8	6	7	22	26	8	4	1	88

DISTANCE FROM CENTER $2'.0$ TO $2'.9$

Limits of Photo-visual Magnitude	<*b*5	*b*5 to *a*0	*a*0 to *a*5	*a*5 to *f*0	*f*0 to *f*5	*f*5 to *g*0	*g*0 to *g*5	*g*5 to *k*0	*k*0 to *k*5	>*k*5	All Colors
12.20–.39										1	1
.40–.59											
.60–.79											
.80–.99									1		1
13.00–.19								3	2		5
.20–.39								1	1		2
.40–.59									1		1
.60–.79											
.80–.99							2	2			4
14.00–.19								4	1		5
.20–.39							3	3			6
.40–.59						6	1				7
.60–.79						3	6	1			10
.80–.99								1			1
15.00–.19			1	1		2	7	2			13
.20–.39			2		5	3	7	1			18
.40–.59		2	7	1	3	5	1				19
.60–.79		2	3	1	1	9	4	1			21
.80–.99		1	5		1	7	3				17
16.00–.19	1		1		2	5	4				13
.20–.39		1			1	5					7
.40–.59				2	6	14					22
.60–.79			1	2	5	7					15
.80–.99		1		3	11						15
Total	1	7	20	10	35	66	38	19	6	1	203

TABLE VIII—*Continued*

DISTANCE FROM CENTER 3'.0 TO 3'.9

Limits of Photo-visual Magnitude	$<b5$	*b*5 to *a*0	*a*0 to *a*5	*a*5 to *f*0	*f*0 to *f*5	*f*5 to *g*0	*g*0 to *g*5	*g*5 to *k*0	*k*0 to *k*5	$>k5$	All Colors
12.40–.59									1		1
.60–.79											
.80–.99									1		1
13.00–.19								1			1
.20–.39									1		1
.40–.59						1					1
.60–.79											
.80–.99								2			2
14.00–.19						1					1
.20–.39											
.40–.59						4	2				6
.60–.79	1					3	3				7
.80–.99							1				1
15.00–.19						1	3				4
.20–.39					1	2	4				7
.40–.59		1	4	2	6	7					20
.60–.79			1	1		5	2				9
.80–.99			1		1	5					7
16.00–.19			1		2	1	1				5
.20–.39					3	3	1				7
.40–.59		1			5	2					8
.60–.79					7	2					9
.80–.99				6	12	1					19
Total	1	2	7	9	37	38	17	3	3	0	117

DISTANCE FROM CENTER 4'.0 TO 5'.9

Limits of Photo-visual Magnitude	$<b5$	*b*5 to *a*0	*a*0 to *a*5	*a*5 to *f*0	*f*0 to *f*5	*f*5 to *g*0	*g*0 to *g*5	*g*5 to *k*0	*k*0 to *k*5	$>k5$	All Colors
12.40–.59										1	1
.60–.79											
.80–.99											
13.00–.19								1			1
.20–.39											
.40–.59								3			3
.60–.79							1	2			3
.80–.99							1				1
14.00–.19							1	1			2
.20–.39											
.40–.59					1	4	2				7
.60–.79						3	1				4
.80–.99						1	3	1			5
15.00–.19				1			4				5
.20–.39			1	2	5	6	2				16
.40–.59		3	3	5	3	4					18
.60–.79		4	2			8	1				15
.80–.99					1	4	1				6
16.00–.19	1	1			3	2					7
.20–.39				1	6	2					9
.40–.59				2	6	2					10
.60–.79			1	9	6	1	1				18
.80–.99			1	10	14						25
Total	1	8	8	30	45	37	18	8	0	1	156

TABLE VIII—*Continued*

DISTANCE FROM CENTER $\geqq 6'.0$

Limits of Photo-visual Magnitude	$<b5$	$b5$ to $a0$	$a0$ to $a5$	$a5$ to $f0$	$f0$ to $f5$	$f5$ to $g0$	$g0$ to $g5$	$g5$ to $k0$	$k0$ to $k5$	$>k5$	All Colors
<12.00	....	....	....	1	....	....	....	1	1	....	3
12.00–.19	....	....	....	....	....	....	....	....	....	....	....
.20–.39	....	....	....	....	....	....	....	....	....	....	....
.40–.59	....	....	....	....	....	....	....	....	....	....	....
.60–.79	....	....	....	....	....	1	....	1	....	2	4
.80–.99	....	....	....	....	....	1	....	....	2	....	3
13.00–.19	....	....	....	....	....	....	....	....	....	....	....
.20–.39	....	....	....	....	....	....	....	....	....	....	....
.40–.59	....	....	....	....	....	....	....	1	....	....	1
.60–.79	....	....	....	....	....	....	3	1	....	....	4
.80–.99	....	....	....	....	1	....	4	2	....	....	7
14.00–.19	....	....	1	....	....	1	1	....	....	....	3
.20–.39	....	....	....	....	....	1	....	....	....	....	1
.40–.59	....	1	....	1	2	2	1	....	....	....	7
.60–.79	....	....	....	1	1	2	1	1	....	....	6
.80–.99	....	....	....	1	1	2	3	2	....	....	9
15.00–.19	....	....	....	....	....	4	3	1	....	....	8
.20–.39	....	1	1	2	4	8	....	....	....	....	16
.40–.59	....	3	9	4	3	10	....	....	....	....	29
.60–.79	....	2	....	2	1	6	1	1	....	....	13
.80–.99	....	1	....	....	4	1	1	....	....	....	7
16.00–.19	....	1	....	....	5	6	1	....	....	....	13
.20–.39	1	....	....	3	6	3	....	1	....	....	14
.40–.59	....	....	....	5	4	1	....	....	....	....	10
.60–.79	....	....	....	9	8	1	....	....	....	....	18
.80–.99	....	1	3	5	1	....	....	....	....	....	10
Total	1	10	14	34	41	50	19	12	3	2	186

DISTANCE FROM CENTER $2'.0$ TO $11'.3$

Limits of Photo-visual Magnitude	$<b5$	$b5$ to $a0$	$a0$ to $a5$	$a5$ to $f0$	$f0$ to $f5$	$f5$ to $g0$	$g0$ to $g5$	$g5$ to $k0$	$k0$ to $k5$	$>k5$	All Colors
<12.00	....	....	....	1	....	....	....	1	1	....	3
12.00–.19	....	....	....	....	....	....	....	....	....	....	....
.20–.39	....	....	....	....	....	....	....	....	....	1	1
.40–.59	....	....	....	....	....	....	....	....	1	1	2
.60–.79	....	....	....	....	....	1	....	1	....	2	4
.80–.99	....	....	....	....	....	1	....	....	4	....	5
13.00–.19	....	....	....	....	....	....	....	5	2	....	7
.20–.39	....	....	....	....	....	....	....	1	2	....	3
.40–.59	....	....	....	....	....	1	....	4	1	....	6
.60–.79	....	....	....	....	....	....	4	3	....	....	7
.80–.99	....	....	....	....	1	....	7	6	....	....	14
14.00–.19	....	....	1	....	....	2	2	5	1	....	11
.20–.39	....	....	....	....	....	1	3	3	....	....	7
.40–.59	....	1	....	1	3	16	6	....	....	....	27
.60–.79	1	....	....	1	1	11	11	2	....	....	27
.80–.99	....	....	....	1	1	3	7	4	....	....	16
15.00–.19	....	....	1	2	....	7	17	3	....	....	30
.20–.39	....	1	4	4	15	19	13	1	....	....	57
.40–.59	....	9	23	12	15	26	1	....	....	....	86
.60–.79	....	8	6	4	2	28	8	2	....	....	58
.80–.99	....	2	6	....	7	17	5	....	....	....	37
16.00–.19	2	2	2	....	12	14	6	....	....	....	38
.20–.39	1	1	....	4	16	13	1	1	....	....	37
.40–.59	....	1	....	9	21	19	....	....	....	....	50
.60–.79	....	....	2	20	26	11	1	....	....	....	60
.80–.99	....	2	4	24	38	1	....	....	....	....	69
Total	4	27	49	83	158	191	92	42	12	4	662

TABLE IX

COLOR-CLASS, DISTANCE, AND PHOTO-VISUAL MAGNITUDE

(Summary of Table VII)

Interval of Distance	Color-Class						All Colors	Average Color-Index
	b	*a*	*f*	*g*	*k*	*m*		
1'.3–1'.9	15.95(6)	15.62(14)	15.75(29)	15.02(34)	13.18(5)	....	15.32(88)	+0.68
2.0–2.4	16.14(4)	15.94(19)	16.05(61)	14.99(35)	13.62(2)	12.33(1)	15.66(122)	+0.64
2.5–2.9	15.70(4)	15.85(11)	15.96(40)	14.64(22)	13.22(4)	....	15.44(81)	+0.66
3.0–3.4	....	16.04(10)	16.03(48)	14.74(12)	13.09(2)	....	15.74(72)	+0.61
3.5–3.9	15.54(3)	16.22(6)	15.83(27)	15.26(8)	12.47(1)	....	15.68(45)	+0.56
4.0–4.9	15.76(4)	16.30(19)	16.04(44)	14.45(13)	....	12.48(1)	15.79(81)	+0.54
5.0–5.9	15.73(5)	16.27(19)	15.88(38)	14.71(13)	....	....	15.76(75)	+0.52
6.0–7.0	16.06(2)	16.14(19)	15.91(27)	13.84(8)	....	....	15.70(56)	+0.48
7.1–9.0	15.37(5)	16.02(18)	15.70(30)	14.39(11)	12.87(2)	12.60(1)	15.41(67)	+0.54
9.1–11.3	15.97(4)	15.44(11)	15.38(34)	14.82(12)	11.68(2)	....	15.20(63)	+0.61
1'.3–11'.3	15.79(37)	16.01(146)	15.86(378)	14.78(168)	12.99(18)	12.47(3)	15.57(750)	+0.59
Outside Distance 2'	15.76(31)	16.06(132)	15.89(349)	14.71(134)	12.91(13)	12.47(3)	15.61(662)	+0.58

TABLE X

THE COLOR OF GIANT STARS

Interval of Photo-visual Magnitude	Number of Stars	Average Color-Index
12.0–12.6..........	3	+1.43
12.6–13.2..........	16	+1.18
13.2–13.8..........	16	+1.06
13.8–14.4..........	32	+0.94
14.4–15.0..........	70	+0.74
15.0–15.6..........	173	+0.52
15.6–16.2..........	133	+0.54
16.2–16.8..........	147	+0.50

MOUNT WILSON OBSERVATORY
October 1919

OBSERVATIONS OF THE ELECTRIC FURNACE SPECTRA OF COBALT, NICKEL, BARIUM, STRONTIUM, AND CALCIUM IN THE REGION OF GREATER WAVE-LENGTH[1]

By ARTHUR S. KING

The material presented in this paper was collected during a series of experiments designed to extend as far as possible into the infra-red several furnace spectra which had previously been studied through the range λ 3000 to λ 7000.[2]

Since photographic emulsions stained with dicyanin are sensitive far beyond the red limit of the visible spectrum, it is possible to observe the characteristics of infra-red lines without extraordinary difficulties. For the weaker light-sources, however, faster plates than those now available are highly desirable, and this lack of speed has been much felt in the photography of furnace spectra. It has been noted repeatedly in former furnace investigations that the region of greater wave-length is relatively weak in the furnace. The present study of the infra-red bears out this observation, and long exposures were often required to bring out the spectra that have been obtained. It has been possible, however, to photograph the spectrum to about λ 9200 and to classify the lines which the furnace was able to emit within this range.

Seed "23" plates or Eastman Portrait Films were treated with a dicyanin bath according to the method recommended by Merrill.[3] The plates were used for the first-order spectrum of the 15-ft. concave grating to about λ 8250, while the films exposed with a 1-meter concave grating gave the extension farther into the infra-red.

The tube-resistance furnace was operated as usual *in vacuo*, and photographs were made for three temperature stages selected according to the element under examination. This treatment

[1] *Contributions from the Mount Wilson Observatory*, No. 181.

[2] *Mt. Wilson Contr.*, Nos. 108, 150; *Astrophysical Journal*, **42**, 344, 1915; **48**, 13, 1918.

[3] *Bulletin of the Bureau of Standards*, **14**, 487, 1919.

brought out the groups of lines appearing at the successive temperatures and showed the relative changes in line intensity as the temperature rises.

The resulting classification is given in the last column of Tables I–IV and follows the method of previous work. Lines of Classes I and II appear at low temperatures; those of Class II strengthen more rapidly at higher temperatures and are usually strong arc lines. Class III lines appear at medium temperature, while those of Classes IV and V are high-temperature lines. Those lines which are especially characteristic of the furnace spectrum and are relatively faint in the arc are denoted by "A" after the class number. The predominating lines of this type are those of Classes I A and III A.

COBALT

The cobalt lines obtained in this investigation are listed in Table I, the wave-lengths (and also those of Table II) being the measures of Meggers and Kiess,[1] which are on the international system. The metal used in the furnace was a purified powder prepared by Kahlbaum.

The results are presented in the usual form, with intensities for the arc and three furnace temperatures. The latter were approximately 2400°, 2100°, and 1900° C. Some of the low-temperature lines as far as λ 7085 were also listed in the former tables.[2] The classification of these lines remains the same, but the relative intensities are changed owing to the use of dicyanin plates. The low-temperature spectrograms required long exposure, and, in order to make sure that all possible lines for this temperature were recorded, the results with the 15-ft. spectrograph were checked by a strongly exposed film taken with the 1-meter concave grating.

The variety of types observed for the visible spectrum continues in the region of longer waves. A number of moderately strong arc lines did not appear in the furnace and are placed in Class V. Two very faint arc lines λλ 7250 and 7437 are relatively strong in the furnace. The low-temperature spectrum ceases at λ 7417, but

[1] *Bulletin of the Bureau of Standards*, **14**, 637, 1919.

[2] *Mt. Wilson Contr.*, No. 108; *Astrophysical Journal*, **42**, 344, 1915.

that for medium temperature holds up to the end of the list at λ 8094.

TABLE I

TEMPERATURE CLASSIFICATION OF COBALT LINES

λ (Meggers and Kiess)	Arc Intensity	Furnace Intensities			Class
		High Temperature	Medium Temperature	Low Temperature	
6678.84	5	5	4	2	II
6771.05	50	50	40	40	I
6814.99	40	40	30	25	I
6872.42	40	40	30	20	I
6937.85	4	2	1	....	III
6997.30*	4	....	....	....	V
7004.82	3	3	2	....	III
7016.65	35	35	25	25	I
7027.86	6	tr	....	....	V
7052.84	60	60	40	50	I
7054.08	10	8	5	....	III
7084.99	100	80	80	80	I
7094.64	1	1	....	....	IV
7113.74	5	....	....	....	V
7124.45	1	1	1	....	III
7134.37	5	....	....	....	V
7154.71	8	8	6	2	II
7159.23	6	....	....	....	V
7193.63	4	....	....	....	V
7250.09	1	3	2	....	III A
7285.29	4	1	....	....	IV
7354.61	3	4	2	....	III
7388.66	5	2	1	....	III
7417.40	10	10	5	2	II
7437.15	1	2	1	....	III A
7457.43	6	....	....	....	V
7533.52	1	1	....	....	IV
7554.04	4	1	....	....	IV
7590.60	2	2	1	....	III
7606.30	2	....	....	....	V
7610.29	2	1	....	....	IV
7712.68	6	5	2	....	III
7838.18	3	....	....	....	V
7869.92	2	....	....	....	V
7871.43	2	....	....	....	V
7908.75†	6	3?	3?	....	III?
7926.59	3	....	....	....	V
7987.38	5	5	3	....	III
8007.34	5	....	....	....	V
8043.33	2	....	....	....	V
8056.03	2	....	....	....	V
8094.03	8	4	2	....	III

* Probably double.

† Furnace line may be due to carbon.

NICKEL

The nickel lines listed in Table II were obtained for about the same temperature stages as the cobalt lines in Table I. The

TABLE II

TEMPERATURE CLASSIFICATION OF NICKEL LINES

λ (Meggers and Kiess)	Arc Intensity	Furnace Intensities			Class
		High Temperature	Medium Temperature	Low Temperature	
6842.10	8	....	....	....	V
6876.77	2	2	....	....	IV
6914.60	50	50	20	15	II
6955.10	3	....	....	....	V
7001.55	1	1	....	....	IV
7024.76	3	....	....	....	V
7030.10	3	....	....	....	V
7034.42	1	....	....	....	V
7110.98	3	15	8	....	III A
7122.31*	100	4?	2?	....	IV?
7182.06	8	....	....	....	V
7197.07	5	15	5	....	III A
7261.94	3	8	3	....	III A
7291.30	1	3	1	....	III A
7385.23†	1	1?	....	....	IV?
7386.24†	1	3?	2?	....	III A?
7393.67	10	2	1	....	III
7409.35	8	1	....	....	IV
7414.51	2	6	4	....	III A
7422.34	15	4	3	....	III
7522.87	3	2	1	....	III
7525.18	2	1	tr	....	III
7555.67	5	2	2	....	III
7574.10	1	....	....	....	V
7617.02	5	2	1	....	III
7619.24	1	1	tr	....	III
7714.27	3	8	8	6	I A
7727.68	3	1	....	....	IV
7748.94	3	tr	....	....	IV
7788.95	2	6	6	....	III A
7797.66	3	....	....	....	V

* Difficult on account of strong carbon spectrum. Line, if present, is faint in furnace.
† Furnace lines may be due to carbon.

metallic nickel was a purified preparation from Kahlbaum. In some cases cobalt and nickel were used together in the furnace.

The low-temperature stage, at which many lines appear in the visible spectrum, shows in the region now studied only λλ 6915 and 7714. About one-fourth of the lines in Table II, however, are relatively strong in the furnace as compared with the arc. The

most notable of this type is the I A line λ 7714, the others belonging to Class III A. This feature causes the occurrence of various contrasting pairs of neighboring lines, one of which is a decided arc line and the other a furnace line. Such pairs are λλ 7111 and 7122, 7414 and 7422, 7714 and 7728, 7789 and 7798. The relative intensities of the members of any of these pairs in a given source will decide its resemblance to the furnace or the arc.

BARIUM

The barium lines in Table III were obtained at temperatures of 2400°, 2000°, and 1650° C. for the three stages. Desiccated

TABLE III

TEMPERATURE CLASSIFICATION OF BARIUM LINES

λ	Measured by	Arc Intensity	Furnace Intensities			Class
			High Temperature	Medium Temperature	Low Temperature	
6772.07	H	2n	1	1	....	III
6865.93	H	30	10	6	3	II
6868.04*	H	8n	2	?	....	IV?
7060.26†	H	400r	200R	100	40	II
7090.51	H	5n	5	3	....	III
7120.73	H	200	100	40	20	II
7153.72	S	5	5	2	....	III
7195.71	H	80	40	30	4	III
7208.50	H	1n	1	1	....	III
7213.83	H	1	6	4	....	III A
7229.40	H	25	10	5	....	III
7280.58	H	150r	100R	40	15	II
7359.67	H	1	4	2	....	III A
7376.10	H	2n	2	1	....	III
7392.83	H	30	15	12	4	II
7410.6	S	1	1	....	....	IV
7417.80	H	5	6	5	2	II
7460.27	H	5n	5	2	....	III
7488.38	H	10	10	10	8	I
7610.50	M	2	4	4	....	III A
7636.88	M	2n	3	2	....	III
7642.92	M	4n	4	2	....	III
7672.12	M	25r	20r	15	12	I
7706.58	M	1n	1	1	....	III
7780.49	M	10	10	8	7	I
7905.80	M	6	6	6	1	III
7911.36	M	3	3	6	10	I A
8210.28‡	M	4	3	2	?	III?
8559.90	M	4	3	2	2	I

* Difficult at medium temperature on account of band.
† Intensities much affected by vapor density.
‡ May be concealed by band at low temperature.

barium chloride was used in the furnace. First-order plates taken with the 15-ft. concave grating supplied the data except for the last two lines, which were photographed on films with the 1-meter concave grating.

The wave-lengths are those measured by Hermann,[1] by Saunders,[2] and by Meggers,[3] as indicated by the initials in the second column. The values of Meggers are on the international system.

The low-temperature spectrum yields a considerable number of lines in this region. Besides the strong arc lines of Class II, which are present at low temperature, there is an important set of five Class I lines, of which the I A line λ 7911 is the most interesting. This line widens at high temperature and its low density may be due to incipient reversal, but the high intensity of this weak arc line at low temperature is very striking. Several lines just visible in the arc with moderate exposure attain considerable strength at the high and medium furnace temperatures and are placed in Class III A. Lines which in the arc show a diffuse structure are indicated by "n" after the arc intensity. Some of these are shaded toward red or violet. In all such cases the vacuum furnace gives a sharply defined line. Three lines, λλ 7060, 7281, 7672, are reversible both in the arc and in the high-temperature furnace. The reversals are narrow, however, compared with those of the potassium pair λλ 7665, 7699, which, though given merely by an impurity, often appear widely reversed.

STRONTIUM

The strontium lines in Table IV were obtained with the dried chloride in the tube at the same temperatures as were used with barium. No lines showed a higher relative intensity in the furnace than in the arc. λ 6892.62 is the most conspicuous low-temperature line, the only one falling in Class I. The other strong lines fade rapidly at low temperature. λ 7153.08 seems usually to have been ascribed to barium, which has a line at λ 7153.72,

[1] *Tübingen Dissertation*, 1904; *Annalen der Physik* (4), **16**, 684, 1905.

[2] *Astrophysical Journal*, **32**, 153, 1910.

[3] *Bulletin of the Bureau of Standards*, **14**, 371, 1918.

but the two lines are clearly shown by these photographs to be distinct.

TABLE IV

TEMPERATURE CLASSIFICATION OF STRONTIUM LINES

λ (MEGGERS)	ARC INTENSITY	FURNACE INTENSITIES			CLASS
		High Temperature	Medium Temperature	Low Temperature	
6791.08.....	100	20	20	5	II
6878.36.....	300	40	30	10	II
6892.62.....	50	50r	50	50	I
7070.15.....	400	100	100	30	II
7153.08*....	5	1 ?	....	....	IV?
7167.24†....	50	10	4	....	III
7232.24‡....	20	6	2	....	III
7287.44.....	1	1	....	....	IV
7309.47.....	70	15	10	1	III
7621.54.....	10	4	2	....	III
7673.11§....	15	4	1	....	III

* Furnace line may be due to carbon.
† Widens to red in arc.
‡ Widens to red in arc.
§ Widens to violet in arc.

CALCIUM

Spectrograms were made with metallic calcium in the furnace for the same temperatures as were used with barium and strontium. The lines measured by Meggers at λλ 7148.15, 7202.21, 7326.12 were obtained with the furnace. These come within the range covered in the former investigation.[1] Numerous attempts were made to photograph the lines λλ 8497.98, 8542.06, 8662.10, but these, while strong in the arc, did not appear with certainty in the furnace, though a trace of the strongest may have been present. These lines are of special interest as in the solar spectrum they are the strongest in that part of the infra-red at present reached by photography. This high solar intensity and the fact that they are stronger in the spark than in the arc are features which they have in common with the H and K lines. They are, however, enhanced lines of a more pronounced type than H and K, the latter appearing even at low temperatures in the furnace, while those of the infra-red triplet belong clearly in Class V.

[1] *Mt. Wilson Contr.*, No. 150; *Astrophysical Journal*, **48**, 13, 1918.

SUMMARY

1. By means of plates bathed with dicyanin, a study of the cobalt, nickel, barium, strontium, and calcium spectra extending into the infra-red has been made for three temperatures of the electric furnace.

2. The lines of the arc spectrum, above a certain minimum intensity, appear for the most part in the furnace. Some strong arc lines, however, were not obtained in the furnace, and, on the other hand, a number of examples appear of lines strong in the furnace which are faint in the arc.

3. Besides these features, the same variety as to rate of increase of line intensity with temperature was observed as for the visible spectrum, and the resulting classification is based on the differing response to varying temperature.

MOUNT WILSON OBSERVATORY
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THE ORBITS OF THE SPECTROSCOPIC COMPONENTS OF BOSS 5026

By W. E. HARPER

ABSTRACT

Spectroscopic binary Boss 5026 (mag. 6.3; type F5). A series of twenty-nine plates secured during the summer has enabled the *elements of both orbits* to be determined with considerable accuracy. The results are given in a table and are also shown graphically. The period is 7.638 days; the *masses* are nearly equal, 1.854 and 1.827☉; the *velocity of the system* is about −15.6 km.

This star (1900: $\alpha = 19^h36^m4$; $\delta = +50°44'$; photographic magnitude 6.3; type F5) was found to be a binary from the double lines shown on the first plate made. Twenty-nine plates were secured during the summer, all but four of which have been used in the present solution. These four, taken before the approximate period was known, fall at a phase in the orbit where the spectra are partially superposed and hence are unmeasurable. Of the remaining twenty-five, all but four have both components measurable, so that the determination of the orbit rests on the equivalent of forty-six plates. All were made on Seed 30 emulsion with the single-prism spectrograph which has a dispersion at the central ray λ 4200 of 25.7 angstroms per millimeter.

The spectra of the two components are quite similar, the difference in intensities being barely sufficient to enable one to tell from inspection to which component each set of lines belongs. The lines of both components are fuzzy in nature, but as about a dozen on the average were measured in each case, a fairly reliable result was obtained, the probable error of a plate for component 1 (the one with the more intense lines) being ±2.1 and for the other ±2.5 km per sec. The masses, as may be expected, are very nearly equal, component 2 having a mass 0.986 times that of component 1.

The period was obtained early in the observations, thus avoiding to a large extent useless plates at phases where the lines would be hopelessly mixed. In addition, this knowledge of the general

form of the curve made possible the securing of separated spectra close to the crossing points by narrowing the collimator slit from its usual width of 0.051 mm. Nicely resolved lines were secured where the difference in velocity was of the order of 70 km per sec., and in one case a difference of 60 km gave lines clearly double in the violet region.

From the preliminary elements given later, observation equations were built up according to the notation of Lehmann-Filhés, modified to suit cases of double spectra,[1] and a least-squares solution effected. As no early observations existed whereby the preliminary value of the period might be corrected, this term was

TABLE OF ELEMENTS

Element	Preliminary	Final
Period . . . . P	7.635 days	7.6383 days ±.0019 days
Eccentricity . . . . e	0.55	0.527 ±0.006
Longitude of apse . . . . ω_1	48°	46°.74 ±0°.81
Longitude of apse . . . . ω_2	228°	226°.74 ±0°.81
Velocity of system . . . . . . γ	−16.26 km	−15.59 km ±0.36 km
Semi-amplitude primary . . . K_1	92 km	89.81 km ±0.69 km
Semi-amplitude secondary . . K_2	92 km	91.12 km ±0.71 km
Periastron passage . . . . . . T	J.D. 2,422,201.405	J.D. 2,422,398 ±0.007
Semi-major axis . . . . . . $a_1 \sin i_1$	. . . .	8,017,000 km
Semi-major axis . . . . . . $a_2 \sin i$	. . . .	8,134,000 km
Mass primary . . . . $m_1 \sin i$	. . . .	1.854 ☉
Mass secondary . . . . . $m_2 \sin i$	. . . .	1.827 ☉

also included in the solution. This practically necessitated treating all the observations separately, and only where they were taken on one night or where they fell on a smooth part of the curve was this principle departed from. In this connection the four plates showing single lines, which group themselves symmetrically about one of the crossing points, were formed into one normal place. Thus a set of thirty-five observation equations involving the seven unknowns were built up, whose solution gave small corrections to the preliminary elements, as may be noted in the foregoing table. One solution was seen to be sufficient, as judged by the agreement of the ephemeris residuals and those obtained by substituting directly in the observation equations. The sum

[1] *Dominion Observatory Publications*, 1, 327.

of the squares of the residuals for the normal places was reduced from 527 to 386, about 27 per cent.

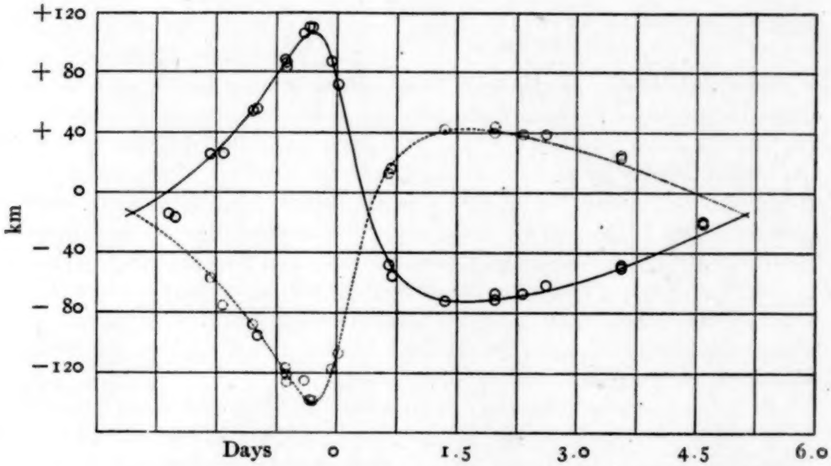

FIG. 1.—Radial velocity curves of Boss 5026 showing individual observations

The graph shown represents the final elements, the continuous curve being that of the so-called component 1, the dotted curve that of the other. Individual observations are plotted.

DOMINION ASTROPHYSICAL OBSERVATORY
VICTORIA, B.C.
November 7, 1919

PREPARATION OF ABSTRACTS

Every article in the *Astrophysical Journal*, however short, is to be preceded by an abstract prepared by the author and submitted by him with the manuscript. The abstract is intended to serve as an aid to the reader by furnishing an index and brief summary or preliminary survey of the contents of the article; it should also be suitable for reprinting in an abstract journal so as to make a reabstracting of the article unnecessary. Therefore, *the abstract should summarize the information completely and precisely*, and also, in order to enable a reader to tell at a glance what the article is about and to enable an efficient index of the subject-matter of the abstract to be readily prepared, *the abstract should contain a set of subtitles which together form a complete and precise index of the information contained in the article.*

In the preparation of abstracts, authors should be guided by the following rules, which are illustrated by the abstracts appearing in the *Astrophysical Journal* for January and March 1920.[1] First the new information contained in the article should be determined by a careful analysis; then the subtitles should be formulated; and finally the text should be written and checked.

RULES

1. *Material not new* need not be analyzed or described; a valuable summary of previous work, however, should be noted.

2. *The subtitles should together include all the new information;* that is, every measurement, observation, method, improvement of apparatus, suggestion, and theory which is presented by the author as new and of value in itself.

3. *Each subtitle should describe the corresponding information so precisely* that the chance of any investigator's being misled into thinking the article contains the particular information he desires when it does not, or vice versa, may be small. "Zeeman effect for electric furnace spectra" is too broad unless all metals have been studied, for an investigator may be interested, at the time, in only one metal; but "Infra-red arc spectrum of iron to 3μ" evidently satisfies this rule. It is particularly desirable that ranges of variation of temperature, wave-length, pressure, etc., be given.

4. *The text should summarize the author's conclusions and should transcribe all numerical results of general interest*, including all that might be looked for in a table of astronomical and physical constants, with an indication of the

[1] The rules and illustrative abstracts were prepared by G. S. Fulcher, of the National Research Council.

accuracy of each. It should give all the information that anyone, not a specialist in the particular field involved, might care to have in his notebook.

5. *The text should be divided into as many paragraphs* as there are distinct subjects concerning which information is given. Parts of subtitles may be scattered through the text but the subject of each paragraph must be indicated at the beginning.

6. *Complete sentences* should be used except in the case of subtitles. The abstract should be made as readable as the necessary brevity will permit.

NOTICE TO CONTRIBUTORS

There is occasionally published in the *Astrophysical Journal* a Standing Notice (for instance, on pages 179–180 of the number for September 1917). This is principally intended to guide contributors regarding the manuscript, illustrations, and reprints. This notice contains the following paragraph:

> Where unusual expense is involved in the publication of an article, on account of length, tabular matter, or illustrations, arrangements are made whereby the expense is shared by the author or by the institution which he represents, according to a uniform system.

The present sheet has been printed for amplifying further that paragraph.

The "uniform system" according to which "arrangements are made" is as follows: The cost of composition in excess of $50, and of stock, presswork, and binding of pages in excess of 40 pages, for any one article shall be paid by the author or by the institution which he represents at the current rates of the University of Chicago Press. When four articles from one institution or author have appeared in any one volume, on which the cost of composition has amounted to $50 each, or when the total cost of composition incurred by the *Astrophysical Journal* on articles for one institution has reached the sum of $200, the entire cost of the composition, stock, presswork, and binding of any additional articles appearing in that volume shall be paid by the author or by the institution which he represents.

As to illustrations, the arrangement cannot be quite as specific, but it may be generally assumed that not more than three half-tone inserts can be allowed without payment by the author. The cost of paper, presswork, and binding for each full-page insert is about $8.00, aside from the cost of the half-tone itself. In the matter of zinc etchings, considerable latitude has to be allowed, as in many cases diagrams take the place of more expensive tables. It may be assumed, however, that it will seldom be possible for the *Journal* to bear an expense of over $25 for diagrams and text illustrations in any one article.

Contributors should notice that since January 1917 it has been impossible to supply any free reprints of articles.

Reprints of articles, with or without covers, will be supplied to authors at cost. No reprints can be furnished unless a request for them is received before the *Journal* goes to press.

Some of the foregoing arrangements have been in effect for several years; others have been reluctantly, but necessarily, adopted by the Editors and Publishers on account of the grave difficulties in publishing an international journal during war times. At the beginning of the war three-fifths of the subscribers to this *Journal* were resident outside of the United States. The University authorities have loyally continued their generous subsidy of about one-half the expense of publication, but it has not been possible to increase this during the present time. It is hoped that the reasonableness of the foregoing "arrangements" will be appreciated by our valued contributors.

THE EDITORS